SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

SEPTEMBER 1898.

GENERAL PHYSICS.

1012. *Energy Losses in Torsion Phenomena.* **H. Bouasse.** (Annal. Chim. Phys. 14. pp. 106–144, 1898.)—Reference is made to a previous paper which appeared in the same journal (see Phys. Soc. Abstracts, No. 643, 1897), and to papers published in the 'Ann. de la Faculté des Sciences de Toulouse,' 1897, 1898. A huge Deprez-D'Arsonval galvanometer was not found suitable for producing sinusoidal alternating torsion in a platinum wire 10 m. long. In the mechanical arrangement adopted, a vertical steel pin carries two pulleys, to which two fine threads are attached. The one thread is of rubber; to its extremity circular motion is imparted by means of a small dynamo and several sets of gearing. An improved dynamometer has been used for measuring the couples. The steel pin described sinusoidal rotations, varying in amplitude between 0° and 400°, and in period between 30 sec. and 1 hour. The researches are not yet completed. H. B.

1013. *Osmose of Liquids through Vulcanised Caoutchouc.* **G. Flusin.** (Comptes Rendus, 126. pp. 1497–1500, 1898.)—The caoutchouc is in the form of sheets 1 mm. thick. Its density at 17° is 0·997; it gives 2 °/₀ of ash, and contains 12·54 °/₀ of sulphur, of which only 1·28 is combined. Placed in the liquids indicated below, it swells and becomes translucent, but preserves its cohesion. The caoutchouc is placed between two perforated discs of sheet-iron. The compound disc, thus produced, divides a vessel into two compartments. In one compartment is placed ethyl alcohol, and in the other the liquid the behaviour of which is to be studied.

To measure the osmotic flow a horizontal tube is attached to each compartment, the rate of flow being indicated by the change in position of the meniscus. In the cases considered the flow always takes place towards the alcohol. Taking the flow of carbon disulphide as 193·8, that of chloroform is 145·3; toluene, 76·0;

ether, 76·0; benzene, 57·0; xylene, 50·3; essence of petroleum, 47·5; benzyl chloride, 13·3; essence of turpentine, 11·4; petroleum oil, 8·5; nitro-benzene, 2·8.

With the object of indicating the cause of the flow the author determines the rate at which a disc of caoutchouc increases in weight when placed in the various liquids. In each case the rate is a maximum at or near the beginning, and diminishes with increase of the time. The experiments show that the rates of osmotic flow are in the same order as the *initial* rates of increase in weight. A. Gs.

1014. *Stress-Strain Relations of Rubber.* **R. H. Thurston.** (Science, 7. pp. 522–523, 1898.)—The author refers to some earlier work, and then says:—"In all cases the substance behaved under load precisely as do other materials in the early part of its strain; then a reversed curve is described, and the test-piece stiffens greatly, and offers continually increasing resistance until at last rupture takes place, without yelding by inelastic deformation at any point of its course. Toward the end of its test the substance yields proportionately to the applied load. The fracture is sharp and without warning, and the break clean and smooth and at right angles to the line of pull. No permanent reduction of section is observable after fracture. The reduced section immediately before breaking is but one-eighth the initial section of the unstrained rubber. Permanent set occurs to an exceedingly slight extent, and its value is dependent upon the maximum load and independent of the elastic properties of the substance. The set of the material would not be noticed in ordinary use. Permanent loads produce permanent continuous extension and in time fracture. This was found to be true for loads rising from 40 to 330 pounds per square inch (2·8 to 23·18 kgs. per sq. cm.), and stress-strain diagrams for two weeks showed steady elongation.

"Plotting curves having for their coordinates loads per unit of area and areas of section of test-piece at point of maximum reduction, the stress-strain diagram thus produced becomes altered in form and similar to those of other materials plotted in the usual manner. It has the same curvature at the initial stage, the same straight line to an (apparent) elastic limit, and finally a steady but slight rise with increasing loads with a sudden break at the end. The highest load measured in these experiments was 810 pounds per square inch (56·7 kgs. per sq. cm.). *The quality employed* in all cases was that of the *stationer's elastic bands*."

The author concludes with a reference to R. A. Fessenden's explanation of the observed phenomena. A. Gs.

1015. *Interferential Calibration of Screws.* **M. Hamy.** (Comptes Rendus, 126. pp. 1772–1774, 1898.)—The author gives a complete account of a somewhat novel method of accurately calibrating the screw of a micrometer or dividing engine. The

method of working out the observations of the interference-fringes is somewhat similar to that employed by Michelson in his work on the value of a metre in light waves, but the apparatus with which the interference is produced is different. A plane mirror, thickly silvered, is placed on the carriage of the micrometer, and opposite to it, but attached to the micrometer-screw, is placed a lens of very slight curvature, the side nearest the plane mirror being half-silvered. The system is illuminated by monochromatic light from a small aperture placed at the focal plane of the lens, the eye being placed at the reflected image of the aperture. Interference-fringes in the form of circles (if glasses be well figured) are seen, and these are varied by turning the micrometer-screw through known distances. From the variation in the number of bands produced, the exact amount by which the lens is advanced or withdrawn with respect to the mirror can be determined, and this then gives a direct comparison of the value of the screw at those positions.
C. P. B.

1016. *Optical Measurements of Length.* **A. Perot** and **Ch. Fabry.** (Comptes Rendus, 126. pp. 1779–1782, 1898.)—The authors describe the continued application of their method of utilising interference-fringes produced between two lightly silvered glass plates. By having a standard pair of plates which have been accurately calibrated, the fringes produced by them can be matched with those produced in another system the distance between which may be some multiple of the standard. They have measured in this way the thickness of a glass cube of 3 cm. side, and hope to apply it to lengths up to 1 metre. C. P. B.

1017. *Compensated Interference Dilatometer.* **A. E. Tutton.** (Roy. Soc. Proc. 63. pp. 208–211, 1898.)—The author describes a form of Fizeau interference dilatometer, which he considers combines the best features of the apparatus described by Benoit and that described by Pulfrich. Besides other improvements, a new principle of compensating for the expansion of the screws of the Fizeau tripod, which supports the object, is introduced, which enhances the sensitiveness of the method so highly as to render it applicable to the determination of the expansion of crystals when only a block of 5 mm. thickness can be procured. The principle of the compensation depends on the fact that aluminium expands 2·6 times as much as platinum-iridium for the same increment of temperature. The author employs a tripod of platinum-iridium, and places upon its transverse table, through which pass the three screws, a disc of aluminium whose thickness is 1/2·6ths of the length of the screws. The space between the lower surface of the glass plate which is laid upon the upper ends of the screws to assist in producing the interference, and the upper surface of the aluminium then remains constant for all temperatures under observation; and if a crystal is laid upon the aluminium compensator, the whole amount of its expansion is available for measurement by the interference method. Hence the method is no longer a relative one, but affords direct absolute measurements of the expansion of the substance investigated. The paper contains a further description of the rest of the expansion apparatus and its mounting, also of the illuminating and observing apparatus. E. C. R.

1018. *Slow Gaseous Diffusion in High Vacua.* **E. Merritt.** (Phys. Rev. 6. pp. 167–169, 1898.)—In high vacua, equalisation of pressure is very slow (Crookes). A lecture-experiment, exaggerating this result, is obtained by exhausting two vacuum-tubes connected by a long capillary tube, so that the molecules from the second tube must, during exhaustion, flow into the first through the capillary tube. The vacua in the two tubes are very different, as shown by the character of discharges through them, when the exhaustion goes beyond 3 or 4 mm. The one may show kathode-rays or fluorescence, while the other still shows an ordinary Geissler discharge. In time they equalise. Curious results arise by varying the connections. A. D.

1019. *Measurement of Small Gaseous Pressures.* **C. F. Brush.** (Science, 7. pp. 730–734, 1898.)—This is a description of a modification of the McLeod vacuum-gauge. The author makes the two tubes in which the mercury rises and whose difference of level is measured of much larger diameter than usual (about 20 mm.), they are made from contiguous parts of the same piece of tubing. The one in which the residual gas is compressed, or the gauge-head, is closed at its upper end by a piece of heavy tubing, which will just slip inside it with the least possible clearance. One end of this piece of tubing is first closed as squarely as possible by fusion, and then ground to a convex spherical surface of a long radius; the tube is then slipped into the gauge-head closed end downwards, and the open ends of the two tubes fused together.

The paper gives details of finding the capacity of the gauge-head, etc., and observing the difference in the levels of the columns by means of a very elaborate cathetometer. The author claims that small pressures can be measured by this apparatus with a probable error of less than a thousandth part of a millionth of an atmosphere. E. C. R.

1020. *Velocity of Earthquake Waves.* **G. Agamennone.** (Roma, R. Accad. Lincei, Atti, 7, pp. 67–73 & 162–166, 1898.)—The author calculates that the velocities of the *initial* disturbances on Aug. 19th, 1895, from Aidin to Padua and Strasburg were respectively 9800 and 3100 metres per second; whilst the velocities of the maximum disturbances were 3200 and 2500 respectively. In the case of the Pergamos earthquake on Nov. 13th–14th, 1895, the velocities from Pergamos to Padua and Nicolaiew were 4500 and 3500 metres per second respectively. He places no great faith in the data on which the calculations are based. A. Gs.

1021. *Velocity of Earthquake Waves.* **G. Agamennone.** (Roma, R. Accad. Lincei, Atti, 7. pp. 265–272, 1898.)—A velocity of 8·3 or 10·6 kilometres per second is obtained for the wave-front of the Indian earthquake of June 12, 1897, the two values being obtained by means of the two times recorded for the start of the earthquake at Calcutta. The velocity of the propagation of the maximum inclination of the earth's surface to the vertical comes out 2·61 or 2·76 kilometres per second. W. W.

1022. *Solar and Lunar Influence on Atmosphere.* **A. Poincaré.** (Comptes Rendus, 126. pp. 1269–1272, 1898.)—The author gives an example of the application of the formula derived in a previous paper for expressing the relations between the solar and lunar attractions and the terrestrial atmospheric pressures. C. P. B.

1023. *Enlargement of Sun at Horizon.* **D. Eginitis.** (Comptes Rendus, 126. pp. 1326–1329, 1898.)—The paper is a *résumé* of the various theories which have from time to time been put forward to account for the apparent enlargement of the discs of the sun and moon at the horizon. The author concludes that, although several of the explanations put forward may have some influence on the phenomenon, the principal determinant of its appearance is yet unknown. C. P. B.

1024. *Wind Pressure and the Moon.* **A. Poincaré.** (Comptes Rendus, 126. pp. 1449–1451, 1898.)—The author discusses the application of the formulæ previously derived (see Comptes Rendus, 126. pp. 1054–5, 1898) for the expression of the attraction between two bodies to the attraction produced between the moon and the earth's atmosphere. Special reference is made to the formation of the polar vortices, and to the effect of harmonic periods in the lunar attraction. C. P. B.

1025. *Planetary Atmospheres.* **G. Johnstone Stoney.** (Ast. Phys. Journ. 7. pp. 25–55, 1898.)—This paper is a reprint from vol. vi. p. 305 of the 'Transactions of the Royal Dublin Society,' and extends that application of the Kinetic Theory of Gas to the investigation of the phenomena of atmospheres which the author had employed in a paper on the "Physical Constitution of the Sun and Stars," published in the 'Proceedings of the Royal Society' for 1868.

In the earlier paper the conditions which limit the height of an atmosphere were investigated, and it was shown that when an atmosphere consists of a mixture of gases, the elevations to which the constituents will range stand in the order of their densities; from which it follows that Dalton's law of the equal diffusion of gases does not extend to the upper regions of an atmosphere.

The inquiry of the present paper is with reference to the conditions which determine whether a gas can be retained by the atmosphere of a celestial body, or will escape from it; and it is shown that the issue depends on the following physical circumstances:—(1st) On the amount of the planet's potential of gravitation at the outskirts of its atmosphere; (2nd) on the tangential speed of the top of the atmosphere over the equator consequent upon the planet's rotation; (3rd) on the speed and direction of the wind in the same situation; (4th) on the greatest speed which can with sufficient frequency be attained by the molecules of the gas at a given temperature and when quiescent, *i. e.*, when there is no wind or other current in the gas; (5th) on the highest temperature of the gas in the upper regions of the atmosphere; and (6th) on the intensity of sunshine upon the gas in the planet's atmosphere, which depends upon absorption in the solar atmosphere, and varies from one gas to another.

Basing his investigation upon these principles, the author explains the absence of hydrogen and helium from the earth's atmosphere, and the absence of all known constituents of an atmosphere from the moon, by showing that in accordance with the Kinetic Theory these gases are so circumstanced upon the earth and moon that their molecules can drift away; and he further arrives at the conclusion that water cannot be a constituent of the atmospheres of either Mercury or Mars.

The conditions which prevail upon Mars are specially discussed.

In the absence of water, it is suggested that nitrogen, argon, and carbon dioxide are the most probable constituents of its atmosphere. The most condensible of these is carbon dioxide, and to it are referred the snow-caps which are formed alternately on the north and south poles of Mars. Carbon dioxide would be the heaviest constituent of such an atmosphere, and would behave differently to water in the earth's atmosphere, of which the vapour of water is its lightest constituent. It is inferred that the vapour upon Mars cannot produce clouds floating at a distance above the solid surface of the planet, as water does in the earth's atmosphere; but only low-lying fogs with frost and snow. To these and to the vapour being distilled towards the two poles alternately, are referred the varying but frequently recurring appearances which observers have recorded upon that planet.

From the circumstances that helium escapes from the earth's atmosphere, and that water does not escape from Venus, it is inferred that the molecules of a gas sufficiently often attain a velocity which is 9 times the velocity of mean square, to produce marked effects in nature, but that a velocity of 18 times the velocity of mean square is a very infrequent physical event.

The investigation also offers an explanation of the gaps in the series of chemical elements which upon the earth seem to exist between hydrogen and helium, and between helium and lithium. It shows that if the suspected intermediate elements exist anywhere upon the earth, it can only be in the form of compounds or as occluded gas; whereas, the conditions upon Jupiter are such that they may all be constituents of his atmosphere, and that some of them may be present in the atmospheres of the three other giant planets of the solar system, though necessarily absent from the atmospheres of the group of four smaller inner planets to which the earth belongs.

By an application of the same method of investigation to the satellites and minor planets of the solar system, it is ascertained that there can be no atmosphere upon any of these bodies, except, perhaps, on the satellite of Neptune; and with reference to the Sun, it is shown that the greatest size which the sun can have had since it became a globe—that is, the greatest which is compatible with its atmosphere having then, as now, contained free hydrogen—is an immense sphere extending out to between where the orbits of Mars and Jupiter now lie; so that from some such immense size as this it may have been since slowly contracting.

Finally, the investigation leads to the conclusion that the molecules of the gases which have from time to time escaped from planets and satellites have but seldom been able to extricate themselves altogether from the solar system; and that accordingly the vast majority of them are now circulating in countless numbers round the sun, like excessively minute independent planets.

AUTHOR.

1026. *Latitude Variation in a Rigid Earth.* **H. Crew.** (Phys. Rev. 6. pp. 153–163, 1898.)—The writer explains how, treating the earth as a rigid body approximately spherical, if it were originally set spinning about an axis not exactly coinciding with the axis of figure, *i. e.* of greatest moment of inertia, the axis of figure would describe a small cone about the invariable axis; and therefore the latitude of any place on the earth's surface, meaning thereby the angle between the plumb-line and the invariable axis, would vary periodically. The period is calculated at approximately 306 days.

A note is added on the adjustment of Maxwell's top. S. H. B.

LIGHT.

1027. *Instrumental Aberrations and Astronomical Diffraction.* **K. Strehl.** (Zeitschr. Instrumentenk. 17. pp. 301–314, 1897.) —Formulæ and tables are given relating to spherical aberration, astigmatism, and chromatic aberration. In obtaining them the author has started with the assumption of a spherical wave interrupted by geometrically circular boundaries, regarding everything else as a modification of the first order. Thus, to a first approximation, his results are confirmed by Lommel's discussion of diffraction through a circular aperture. The general conclusion is that spherical aberration and astigmatism can be reduced to amounts which are practically unimportant; chromatic aberration is the most troublesome defect, but can be partially overcome by increase of focal length. Objectives intended for photographic work should be corrected for those rays which are most active chemically for the object in view; the adjustment of the instrument may be effected by the use of auxiliary glasses.

The author proceeds to discuss the influence of diffraction on observations of such phenomena as a transit of Venus or an eclipse of a satellite of Jupiter. The conclusion is that, with the usual instruments, these phenomena are sensibly the same as they would be according to the geometrical theory. G. B. M.

1028. *Improved Form of Abbe Refractometer.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 18. pp. 107–116, 1898.)—The improvements consist in:—(1) grinding one face of the lower prism to a matt surface, instead of polishing it; (2) removing the small illuminating prism and grinding matt the surface to which it was cemented; (3) providing the case of the upper prism with a metal flap, by adjusting which the instrument is quickly adapted for the three different methods of observation. Descriptions, with figures, are given of the complete instrument with and without heating-apparatus, of a special form for technical purposes and of a special pattern for educational purposes. All these are supplied by Zeiss of Jena. G. B. M.

1029. *Vierordt's Symmetrical Double Slit.* **C. Leiss.** (Zeitschr. Instrumentenk. 18. pp. 116–117, 1898.)—The advantages claimed for the form here described are lightness and trustworthiness in the arrangements for estimating the width of the slit. Price 135 *m.* (R. Fuess, Steglitz bei Berlin.) G. B. M.

1030. *Relative Retardation in the Components of Light in a Crystalline Plate.* **J. Walker.** (Roy. Soc. Proc. 63. pp. 79–90, 1898.)—If the surface of the plate be the plane of xy, the positive axis of z being directed inwards, the relative retardation is $T(n_1-n_2)$, where the velocity of light in air is unity, T is the thickness of the plate, and $n_1\,n_2$ are the positive roots of a biquadratic in n obtained by expressing that $lx+my+nz=1$ is a tangent-plane to the wave-surface. The coefficients of the biquadratic are linear functions of $\sin i$, whence writing the roots of the equation as series proceeding by powers of $\sin i$ and expressing the coefficients as symmetrical functions of the roots, the terms of the series may in general be determined in succession by means of linear equations.

This method does not apply when the plate is perpendicular to an optic axis of a biaxal crystal. In this case the biquadratic may be written in the form

$$n^4+(c_0+c_2\sin^2 i)n^2+b_3\sin^3 i\,.\,n+a_0+a_2\sin^2 i+a_4\sin^4 i=0\,;$$

and neglecting the coefficient of n the roots are

$$\pm(\pi+\rho),\qquad \pm(\pi-\rho),$$

where π, ρ are series proceeding by even and odd powers of $\sin i$ respectively. Assuming, then, that the actual roots are

$$\pi+\rho+\alpha,\qquad -\pi-\rho+\beta,\qquad \ldots\,,$$

the successive terms of the series α, β, γ, δ may be calculated by the former method. The calculation is carried as far as terms of the fourth order, and may easily be extended. AUTHOR.

1031. *Radiation in a Magnetic Field.* **A. A. Michelson.** (Phil. Mag. 45. pp. 348–356, 1898.)—In a former paper (see Abstract No. 22) the author gave particulars of a preliminary examination of the effect of a magnetic field on the spectral lines of various substances. In the present paper he states that the phenomena, when more completely observed, are more complex than was suspected previously. The separate lines produced by the magnetisation are themselves found to be multiple. The following summary of the relations determined are given:—

(1) All spectral lines are *tripled* when the radiations emanate in a magnetic field.

(2) The separation is proportional to the strength of field, and is approximately the same for all colours and for all substances.

(3) Viewed in a plane perpendicular to the magnetic field, the outer lines are polarised parallel to the field and the central line is polarised at right angles to the field.

(4) Viewed in a direction parallel to the magnetic field, the central line *vanishes*, while the outer ones are *circularly* polarised—the shorter waves in the direction of the magnetising current, and the longer waves in the opposite sense.

(5) The "middle line" (of the original triplet) is a symmetrical

triple, the distance between the components being one-fourth that of the "outer line," and therefore also proportional to the strength of field.

(6) The relative intensity of the components varies for different substances and for different lines of the same substance; and accordingly the group may appear as a single line or a double or a triple.

(7) The "outer lines" are unsymmetrical, but are symmetrically placed with respect to the "middle line." The distance between the components is usually one-fourth that between the "outer lines," but in some cases one-sixth.

(8) The *intensity* of the components varies for different spectral lines, and these variations do not always correspond with those of the "central line." The outer groups may accordingly appear as single, double, or multiple lines.

In general it was found that the spectral lines examined could be divided into three types, the visibility-curves of which had decided and distinct peculiarities. The chief factor determining the type to which a line belongs consists in the number of secondary components into which the line of the original triplet can be resolved.

The above phenomena are based on an examination of the eight substances, Mercury, Cadmium, Zinc, Sodium, Thallium, Lithium, Hydrogen, and Helium; and the author mentions that it is possible that the laws enunciated in the paper may have to be modified as the work extends. C. P. B.

1032. *Radiation Phenomena in a Strong Magnetic Field.* **T. Preston.** (Dublin Soc. Trans. 6. pp. 385–391, 1898.)—The author gives a general account of the effects of a strong magnetic field on the spectral lines of a spark source of light placed in it. The paper is illustrated by a plate reproduced from photographs of the spectral lines as modified by the magnetic field. These photographs show the lines 4680 of Zinc and 4678 of Cadmium as resolved into pure triplets, while the lines 4800 of Cadmium and 4722 of Zinc appear as quartets. These and other phenomena are discussed in the paper. (See further, Abstract No. 755.)

AUTHOR.

1033. *Uranium Rays and Condensation of Water Vapour.* **C. T. R. Wilson.** (Cambridge Phil. Soc. Proc. 9. 7. pp. 333–338, 1898.)—Uranium rays produce in moist air which they traverse nuclei on which condensation takes place if a certain degree of supersaturation be exceeded. To produce this degree of supersaturation sudden expansion is necessary, such that the ratio of the final to the initial volume of the air is equal to 1·25—the same limit as was found in similar experiments with Röntgen rays described in a former paper (Phil. Trans. vol. 189. A. 1897, p. 265). Thus nuclei of the same kind are introduced by Röntgen rays and uranium rays; the view is taken that they are identical with the ions to which the conducting-power of the gas under the same conditions is due. AUTHOR.

1034. *Röntgen Rays.* **W. C. Röntgen.** (Annal. Phys. Chem. 64. 1. pp. 18-37, 1898.)—If an opaque plate be arranged between the vacuum-tube and a platinocyanide-barium screen, even pretty close to it, there is some fluorescence, which is cut off when the air situated laterally is sheltered from the impact of Röntgen rays by a thickness of lead. The effect is not due to the bending of rays; but the air, when struck by the rays, sends out Röntgen rays in all directions: so that if our eyes were sensitive to these rays, a vacuum-tube would appear like a lamp in a room filled with tobacco-smoke, and possibly the light from the tube and that from the air would have different colours, though there is at present no means of testing this question (whether the air acts by simple diffused reflection or as a *quasi*-fluorescent substance), for the rays from the air are also photographically active.—For comparative measurements the author uses a simple vertical plate of lead along the mid-line of a table; the fluorescent screen is placed at right angles to this, so that half the screen looks towards the left and half towards the right side of this partition. The two tubes to be compared are placed one on each side of this partition, and each then affects only one half of the screen. In using this it is found that the tubes are very inconstant: they are sensitive to irregularities in the make-and-break (worse with Foucault's than with Deprez' contact-breaker); and when the outbursts of Röntgen radiation follow one another so rapidly that the eye cannot detect any want of continuity in the phosphorescence on the screen, the brightness of the screen depends on the intensity of the radiation from the platinum plate of the discharge-tube, on the kind of rays reaching the screen, on the distance between the screen and the tube, on the absorption undergone by the rays before reaching the screen, on the number of discharges per second, on the phosphorescent afterglow of the screen, and on the radiation to the screen from surrounding objects.—From a flat plate the radiation is equal in all directions up to about 80° from the normal, and the difference is only well-marked at between 89° and 90°. The mode of experiment consisted in flexible photographic films bent to a half-circle half surrounding the source; there is no ascertainable difference between the radiations at different angles; the photographic effect increases, except in extreme cases, with the angle between the source of rays and the photographic plate. There is an analogous case of equality in all directions in optical fluorescence: drop fluorescein into water in a square tank illuminated by white or violet light, and the walls of the columns of fluorescein solution appear the brightest, *i.e.*, where the angle of emanation of the phosphorescence-light is the greatest. Stokes has explained this through the fluorescence-light being much less absorbed by the fluorescein-solution than the exciting rays are. So here, the exciting kathode-rays are much more absorbed by platinum than the induced Röntgen rays. The sharpest shadows are obtained by tilting the platinum away from parallelism with the photographic plate through not more than 80°; and the impression is then the most intense.—In the absence of disturbing-effect from the air, and on condition that the radiations remain of the same kind, the brightness of a fluorescent screen varies inversely as the square of its distance from the source. Splitting a solid into layers makes no difference in its transparency; nor does putting it nearer to or farther from the screen. Rays which have traversed one thickness traverse another more readily (in proportion); so that the specific permeability (fraction of radiation let through a layer of unit thickness) is greater, the thicker the object. When two plates of different substances are equally permeable, this equality disappears if the plates are equally thickened or thinned; with plates of Pt 0·0026 mm. and of Al 0·0299 mm. thick, one Pt=six Al; but two Pt=sixteen Al. Other similar numbers are given for other tubes. The relations between the equivalent thicknesses of two substances vary with the thickness and the nature of the material (*e. g.*, the walls of the vacuum-tube) traversed by the rays before reaching the screen. The author uses a platinum-foil, 0·0026 mm. thick, with 15 holes in it, closed respectively by single, double, . . . 15-fold thicknesses of aluminium, each of 0·0299 mm. thickness. When this is interposed, a glance shows which thickness of aluminium is equal to 0·0026 mm. of platinum. The corresponding number of aluminium thicknesses is called the "window-number," the apparatus being called a "platinum-window." Example: With direct radiations the window-number was 5; on interposing 2 mm. soda-glass, the window-number became 10; the rays filtered through the glass found it relatively easier than before to traverse the aluminium. Rays sent through this platinum-window and then through a dozen photographic films indicated the window-number 10 for the first film and 13 for the last.

Conversely, one and the same substance is differently permeable to rays from different tubes: lowest vacua, least potential of discharge, "softest" tubes, least power of penetration; highest vacua, highest potential of discharge; "hardest" tubes, greatest power of penetration. With the former, window-number say 2; with the latter, may be beyond 15. With the former, simple shadows of the hand; with intermediate exhaustions, good bone-shadows; with the last, bones also permeable.—With one and the same tube the quality and penetrating power of the rays depends upon the action of the contact-breaker (which fluctuates), the length of spark-gap parallel to the tube in the secondary circuit, the introduction of a Tesla transformer, the amount of vacuum, and other uninvestigated changes within the tube itself. Putting a tube on the pump at the lowest sufficient vacuum, with small spark-gap parallel to the tube, the tube is very "soft," the rays absorbable, and the window-number small. Putting in a Tesla transformer, or a spark-gap in series, the tube is "hardened."—With a Tesla transformer in circuit, with narrow tube and wire electrodes, the rays are given off in air at 3·1 mm. Hg, and at still lower vacua in hydrogen. The highest vacuum under which the rays can be given off is beyond 0·0002 mm. Hg.—As the vacuum is increased, the spark-gap must be at the same time lengthened; and when the tube is so "hard" that the spark-gap has to be more than 20 cm. long, the rays will go through 4 cm. of iron. The tube will also become harder through its own continued action: so "hard" that a shadow-photograph of a gunlock at 15 cm. distance can be taken in 12 minutes—a relatively long exposure, because the rays go through the photographic film instead of affecting it. This hardening is due to self-exhaustion, and to some change in the electrodes themselves. A tube, if too hard, can be softened by letting in air, by warming it, by reversing the discharges, or by driving very powerful discharges through it. In the last case, the necessary potential of discharge becomes high, but the rays are very absorbable and the window-numbers low. It appears that the kind of rays emitted depends on the mode of discharge, however this may be attained: the same mode of discharge would give the same Röntgen rays, even at relatively high pressures. The quality of the rays is not affected by the strength of the primary current, assuming that the contact-breaker acts equally at all current-strengths; but their intensity is affected. Therefore (1) the radiations from a tube are mixed, and differ in absorbability and intensity; (2) the composition of the mixture depends on the mode of discharge; (3) different rays are absorbed by different substances; (4) kathode rays resemble Röntgen rays in many respects, and the two discrepancies (*a*) difference of absorbability, and (*b*) the permeability to the two kinds of rays according to the density of the substance not following the same law, may be found bridged over by further researches leading to the discovery of rays of intermediate condition, say the Röntgen rays in ultra-soft tubes and extremely thin windows, or the kathode rays in ultra-hard tubes.

Photographic results follow the fluorescent screen pretty closely, particularly with soft tubes; but with hard tubes the window-number seemed a little lower than with the screen. When a hard and a soft tube bring the two halves of the fluorescent screen to the same brightness, a photographic plate put in place of the screen is less affected by the rays from the hard tube: in the latter the rays go through the film, and will go through 96 films and impress the last one while the first is scarcely over-exposed. For this special reason, hard tubes require longer exposures; very soft tubes need longer exposures on account of their feebler intensity.

In a tube in action, Röntgen rays come not only from a minute area on the antikathode but, more feebly, from the whole plate and a part of the walls of the tube. Kathode rays go in all directions from the kathode, but only feebly except along the axis. When the tube is hard and the platinum antikathode very thin, Röntgen rays start in considerable quantity from the back of the latter; and in very hard tubes the point which most emits Röntgen rays can be shifted away from the antikathode by a magnet.

Continued experiments show no difference in the permeability of any crystal according to the direction of the axis. It is the case that the eye can sometimes perceive the presence of Röntgen rays: this is due to the setting up of fluorescence in the retina; and with hard tubes, looked at through a narrow slit in a lead sheet, it is not difficult, by moving the slit, to get changing luminous figures.—Nothing which may really be referred to diffraction has been discovered, though repeatedly sought for; apparent instances have all been found to be otherwise explicable. A. D.

1035. *Recovery of Röntgen-Ray Tubes.* **V. Machado.** (Comptes Rendus, 126. p. 1341, 1898.)—The tube surrounding the stem of the kathode is wrapped in a flexible metallic sheet of tin, lead, or platinum, or surrounded by an insulated coil of copper wire. With this arrangement, exhausted tubes recover in a few seconds. E. E. F.

1036. *Diffusion in Photographic Development.* **A. Guébhard.** (Comptes Rendus, 126. pp. 1341–1344, 1898.)—When a portion of the developer is divided off from the rest by an inverted watch-glass or similar means, osmotic currents set in across the capillary boundary, tracing dark lines on the plate. The currents always travel from the darker to the lighter portions. The traces are bounded by a brighter ring, where apparently the currents are stopped in their progress and escape upwards in vortices. Colson's "confined-development" effects are probably due to the unequal swelling of the gelatine, and "silhouetting" is most likely an effect of irradiation. E. E. F.

1037. *Lippmann Photographs.* **R. Neuhauss.** (Annal. Phys. Chem. 65. 1. pp. 164–172, 1898.)—The author has succeeded in directly viewing and photographing the fine lamellæ produced in a Lippmann photograph by rays of red light, the intervals between which are of the size of the wave-length of that colour. The sections are obtained by means of a microtome, and are embedded in canada balsam. The magnification used is 4000. Some seven or eight layers are clearly shown on the photographs. The attainment of this result, although difficult, is not very extraordinary in microscopic work. The layers of *Amphipleura pellucida* are 0·00024 mm. apart, while the wave-length of red light is 0·00038 mm. E. E. F.

HEAT.

1038. *Thermal Conductivity of Solid Salts.* **C. H. Lees.** (Mem. Manchester Lit. & Phil. Soc. 42. 5. pp. 1–4, 1898.)—The apparatus used, consisting of a fluid plate through which heat, generated electrically, could flow, and in which the temperature-gradient could be determined, is described in Phil. Trans. 1897. The salt to be measured was tried in fluids of different conductivities, mostly mixtures of alcohol and water, till its presence made no difference to the observed conduction in the fluid. The oxides and sulphides had values higher than water, up to 0·025 for emery-powder. KCl and NaCl gave 0·014, 0·013. Salts containing water of crystallisation mostly gave values near to that for water (0·0014). No important regularities were discovered.

R. A. L.

1039. *Calorimeter for the Human Body.* **W. Marcet.** *Heat evolved by the Human Body.* **W. Marcet** and **R. B. Floris.** (Roy. Soc. Proc. 63. pp. 232–242, 242–255, 1898.)—The apparatus is a large Berthelot calorimeter. A wooden chamber, covered outside with felt and inside with cotton-wool, contains a chamber of copper, carefully polished on the inside, 145 cm. high, 69 cm. wide, 810·4 litres capacity, weighing 62·37 kg. A rise of 1° C. in the temperature of the mass of copper would represent 5832 gramme-calories. The annular space between the two chambers has a breadth of 5 cm. The chambers are closed by a movable panel and a door, manipulated with the help of a tackle. Two fans, one fixed low down in the chamber, the other high up, drive the constantly circulating air through the tin vessel containing the ice, suspended from the ceiling of the chamber; the whole of the air of the chamber is carried through the calorimeter in about two minutes. The thermometers are divided into fiftieths of a degree. As a human body gives out about 90,000 calories during one hour (duration of one experiment), a rise of 1° C. in the temperature of the air in the chamber, amounting to 214 cal., is not of much consequence. The heating of the mass of copper is more to be feared; but the temperature of the copper could easily be maintained within 0°·3. The heating of the revolving-fan bearings proved insignificant; the heat generated by the friction of the blades against the air was determined by special experiments: it amounted to about 6000 cal. for 200,000 revolutions of the fans, which were driven by electric motors, and made together from 1000 to 3000 revolutions per hour. Determinations of the heat lost in the chamber by a 6-litre jar filled with hot water differed by 8 per cent., because the vessel could not be placed in position and taken out again with sufficient rapidity, and for other reasons. The burning of a jet of hydrogen in the chamber gave more concordant results the mean found is 34428 cal. per gramme of H (34462 Favre and Silbermann).

The chamber seems well suited for its purpose, as the subjects could spend an hour in it without experiencing any discomfort. The subject sitting on a stool close to the calorimeter felt neither draught nor perspiration nor want of air. The sublingual temperature fell slightly, by about 0°·2 (0°·45 maximum); but the same falling was observed on sitting quietly in an ordinary room. 5 kg. of ice or more were cut into blocks of 2 or 3 inches diameter. The number of calories given out by one person varied for one subject (26 experiments) between 122,124 and 80,639 cal. per hour. Most of the tests were made after lunch; the influences of age, weight, a heavy meal, fasting, warm clothing, etc. have not yet been studied sufficiently. In a general sense it may be said that 4000 cals. are produced per gramme of oxygen absorbed. These are the means of 36 experiments with three different subjects. But the values varied between 3292 and 5031 for one person, and there is no proportionality. This want of proportionality may be due to a storage of oxygen in the tissues. In some cases fresh air was inspired through the nose and expired through the mouth, and carbonic dioxide determinations were made. The variations stated in this abstract are the largest observed, and concern one of the authors, age 69 years, weight 58 kg. H. B.

1040. *Latent Heat of Vaporisation.* **J. A. Groshans.** (Annal. Phys. Chem. 64. 4. pp. 778-788, 1898.)—[A] Assuming the gaseous laws to hold under one atmosphere at all temperatures, we have, with Regnault's value ·000089578 for the standard density of H, the volume of a gram-molecule of any normal vapour (*i. e.* at its absolute boiling-point T under one atmosphere) given by 81·7836 T c.cm. (see Abstract No. 66, p. 27): hence the specific volume s' of a normal vapour with molecular weight M is 81·78 T/M. [B] Trouton's law further gives $21{\cdot}139\,(T/M)\sqrt{a}$ for the latent heat λ of the normal vapour, where a is either 1 or 1·5. [C] The author has found a new law, viz. $NT/M=27{\cdot}80178\sqrt{x}$, where N is the number of atoms in the molecule and x is a constant for each group of substances.

Taken in pairs, these laws give:—[AB] $s'/\lambda=3{\cdot}86885\sqrt{a}$, or 1 calorie will vaporise so much of any liquid at its boiling-point under 1 atmo as will form $3{\cdot}87/\sqrt{a}$ c.cm. of vapour; [AC] $Ns'=2274{\cdot}73\sqrt{x}$, or the volume of as many grams of a normal vapour as there are atoms in its molecule is $2275\sqrt{x}$ c.cm.; [BC] $N\lambda=587{\cdot}702\sqrt{(ax)}$, or the heat required to vaporise as many grams of a liquid at its boiling-point under 1 atmo as there are atoms in its molecule is $588\sqrt{(ax)}$ calories. The values of λ calculated from [BC] agree very well with those obtained by experiment.

In many cases x is an integer: for water, ether, and a large group it is 5; for the propyl ether group 7, &c.; it is 3 for

$C_3H_6O_2$ and 6 for C_2H_6O, and increases by 1 for every CH_2 added. But for the ethers it is not integral, and for them therefore law [C] seems meaningless.

For ether, toluol, etc., $a=1$; it is 1·5 for water and the alcohols, etc.

[The notation here is quite altered, for the author writes *xsd* for x, *ldw*1*g* for λ, T*sd* for T, &c., and the numbers have been recalculated.] R. E. B.

1041. *Expansion on Vaporisation in Relation to Latent Heat.* **J. A. Groshans.** (Annal. Phys. Chem. 64. 4. pp. 789–793, 1898.)—In a former paper (with the notation of the last Abstract) it is asserted that $\rho x/N \equiv y$ is obviously constant, where ρ is the density of liquid at its boiling-point under 1 atmo. Since the numbers given for y range from 1·6 for water to ·23 for ether, this statement must refer to groups if it has any validity. The expansion, being the ratio of the volumes of the vapour and the liquid from which it is formed, is $\rho s' = 2275\, y/\sqrt{x}$, and is thus the same for all substances with the same x and y. R. E. B.

1042. *Kinetic Theory of Liquids.* **W. Voigt.** (Göttingen Nachrichten, 1. pp. 19–47, 1897; 3. pp. 261–272, 1897.)—The first paper carries further the discussion begun in another memoir (see Phys. Soc. Abstracts, No. 646, 1897), in which two circumstances were purposely omitted from consideration, viz. (1) a possible polymerisation, and (2) a possible change of molecular intrinsic energy during condensation. Now the formula previously deduced for the latent heat, viz.

$$\lambda = \mathrm{BT}\{\log(\rho/\rho') + 1 - \rho'/\rho\},$$

suits the monatomic molecules of Hg very fairly well, but not the polyatomic and little polymerisable benzol at all, showing that in general (2) has greater influence than (1).

Liquids with monatomic molecules are then first considered; for these the above equation holds, which with Clapeyron's equation gives

$$\mathrm{T}(dp'/d\mathrm{T})(1/\rho' - 1/\rho) = \log(\rho/\rho');$$

this becomes

$$(d/d\mathrm{T})(\mathrm{T}\log\rho') = \log\rho$$

on neglect of $1/\rho$ in comparison with $1/\rho'$, and further gives

$$\mathrm{T}\log(\rho/\rho') = \text{const.}$$

on taking ρ const., which is equivalent to the constancy of $\frac{1}{2}c^2$, the gain of potential energy per unit mass on vaporisation. Hence is deducible a simple approximate expression for the difference between the saturation specific heats of the liquid and vapour; and expressions are also given for the pressure at a point in the liquid or gas at a distance from the surface of separation. It is then shown that, if the viscosity-equation for gases holds for liquids too, $\eta/\eta' = \mathrm{R}'^2/\mathrm{R}^2$, where η denotes viscosity and R collision-distance; this gives for mercury $\mathrm{R}'/\mathrm{R} \triangleq 4$, a result only explicable on the distant-action theory of collisions.

Liquids with polyatomic molecules are next investigated, and the assumption is made that the parts of the energy per unit mass of a liquid or gas which are changed by vaporisation or evaporation may be written $\frac{1}{2}k^2\mathrm{V}^2$ or $\frac{1}{2}k'^2\mathrm{V}'^2$, where k, k' are numerics that vary but slightly (if at all) with temperature. Then, proceeding as before, we find

$$k'\alpha' = k\alpha \equiv c/\delta \quad \text{and} \quad k'\rho' = k\rho \exp(-\delta^2);$$

and the latent heat is given by

$$\lambda = \mathrm{BT}\{k'^2 \log(k\rho/k'\rho') + 1 - \rho'/\rho\},$$

from which we get approximately

$$\mathrm{T}^{k'^2} \log(k\rho/k'\rho') = \text{const.}$$

On the assumption that $k' = k$, the data for both benzol and water give $k^2 = \frac{5}{3}$, which may possibly have a general significance. This theory with the former assumption respecting viscosity gives the still greater value $\mathrm{R}'/\mathrm{R} \triangleq 10$ in the case of benzol. Finally, the equation

$$2\mathrm{K}/(\rho + \rho') \triangleq \mathrm{BT}\lambda^2 \log(\rho/\rho')$$

gives K=15,800 and 13,400 atmos for Hg at 100° and 350°, K=12,000 and 1,900 atmos for water and benzol at 0°.

The last paper takes into account the influence of the collisions that occur in the layer that separates liquid from vapour, and also of the continuous variation in position of this layer itself in consequence of the collisions. The former modifies the equation $\rho'/\rho = \exp.(-\gamma^2)$ found in the first paper of the series into $(s-b)/(s'-b) = \exp.(-\gamma^2)$, where s denotes specific volume and $\frac{1}{4}b$ the actual volume of the molecules in unit mass; the latter supplies a correction of the expression of the latent heat which is not, however, verified by calculations from the results of Young's experiments. R. E. B.

1043. *Corrected Value of Rowland's Measurement of the Mechanical Equivalent.* **W. S. Day.** (Phys. Rev. 6. pp. 193–222, 1898.)—The author has compared three of Rowland's thermometers directly with three Tonnelot thermometers which had been completely studied at the Bureau International (two of which were broken in crossing the Atlantic). The Tonnelot thermometers were used exactly according to the directions given by Guillaume, in a specially constructed water-bath, which is described in detail. The Rowland thermometers could not conveniently be used vertically, as Rowland himself used them, but their pressure-coefficients were determined, and correction made for the difference of position. The treatment of them with regard to zero-point was the same as Rowland adopted. The thermometers, when corrected to the absolute scale according to Rowland's tables, showed differences from the Paris hydrogen-scale amounting to 0°·032 as a maximum. Rowland's values for the equivalent are recalculated accordingly, and the results given for each degree from 6° to 36°. The following is an abstract :—

Temp.	J.
6°	4·203
10	4·196
15	4·188
20	4·181
25	4·176
30	4·174
35	4·175

The minimum occurs at 31°·5. $J = 4{\cdot}2 \times 10^4$ at 7°·5.

The temperature-coefficient agrees well with Griffiths' values from 15° to 25°. The absolute values are less than Griffiths' by $\frac{1}{300}$ and less than Schuster's by $\frac{1}{400}$; the discrepancy is almost certainly not due to thermometric difficulties.

An abstract of the work occurs in the Phil. Mag. August 1897, but it contains an error. R. A. L.

1044. *Mechanical Equivalent of Heat.* **J. B. Baille** and **C. Féry.** (Comptes Rendus, 126. pp. 1494–1496, 1898.)—A copper cylinder is placed in a rotating magnetic field, produced by surrounding the cylinder coaxially with a ring to which, in a suitable manner, a two-phase current is supplied. The cylinder tends to rotate, but is prevented, the couple being measured by a balance. The frequency of the current is known, and the work spent on the copper can therefore be readily calculated. The rise in temperature of the cylinder is measured by a thermometer placed in a cavity, cooling corrections being applied. The values of the mechanical equivalent obtained vary from 422 to 426. The work is to be repeated with improved apparatus. A. Gs.

1045. *Numerical Evaluation of the Absolute Scale of Temperature.* **R. A. Lehfeldt.** (Phil. Mag. 45. pp. 363–379, 1898.)—Determinations of absolute temperature depend mainly on the measurement of the pressure-coefficient of a gas (hydrogen or air) and of the cooling-effect on outflow through a porous plug. Chappuis, at the Bureau International, has considerably advanced our knowledge of the former quantity; but the latter has, with one small exception, not been studied since the experiments of Joule and Thomson in the middle of the century. The experimental data are tabulated and discussed, and a theory developed, leading to the equation

$$\log(1+100/T_0) = \frac{1}{1-K_p\epsilon/v}\log(1+100\beta),$$

where T_0=absolute temperature of the freezing-point;
K_P=specific heat at constant pressure;
ϵ=cooling of the gas on expansion, per atmo.;
v=specific volume;
β=pressure-coefficient.

The values of T_0 derived from hydrogen, air, and nitrogen lie between 272°·8 and 273°·3; that for carbon dioxide is less reliable. The true value is probably very close to 273°·0.

When T_0 is found the absolute temperature T can be compared with the temperature t on the constant-volume scale for each gas by means of the equation

$$\log(T/T_0) = \frac{1}{1-K_p\epsilon/v}\log\frac{t+1/\beta}{1/\beta}.$$

A table is given for each gas, and the differences between each pair of gases compared with the difference found experimentally at the Bureau International. It is concluded that the normal (hydrogen) scale only differs from the absolute scale by less than a hundredth of a degree between 0° and 100°; but that it is not yet possible to reduce temperatures to the absolute scale with as high a degree of accuracy as it is possible to record them on the mercury-thermometer and reduce to the normal scale. And that to attain that result, and to settle the value of T_0 to 0°·05, it is necessary—

(*a*) To measure the coefficient of pressure for air, in the same manner as has been done for hydrogen, nitrogen, and carbon dioxide by Chappuis, and to extend the experiments on all four gases to initial pressures lower than one metre of mercury—say for 25, 50, and 75 cm.

(*b*) To redetermine the change of temperature on free expansion for *pure* hydrogen, nitrogen, and carbon dioxide over as wide a temperature as possible, paying particular attention to the question whether the cooling-effect is strictly proportional to the change of pressure, and its variation with the temperature: the experiments on hydrogen being the most important. AUTHOR.

ELECTRICITY.

1046. *Discharging Electricity by Ultra-Violet Light.* **J. Zeleny.** (Phil. Mag. 45. pp. 272–273, 1898.)—Air passed over a negatively charged body subjected to ultra-violet light will negatively charge glass wool through which it is passed, and will pass through chargeless; just as when Röntgen rays are used glass wool will discharge the gas (J. J. Thomson and E. Rutherford, Phil. Mag. Nov. 1896, p. 393); but with Röntgen rays the positive charge carried to the glass wool is less than the negative charge carried when light is used. A. D.

1047. *Stratification in Geissler Tubes.* **H. V. Gill.** (Amer. Journ. Sci. 5. pp. 399–417, 1898.)—The hypothesis is here put forward that the stratification of the electric discharge in Geissler tubes is due to gas-waves somewhat analogous to those which produce the dust figures in a Kundt's tube. This theory is supported by dust figures obtained by electric discharges at various pressures of gas. E. H. B.

1048. *Positive Influx towards the Kathode.* **P. Villard.** (Comptes Rendus, 126. pp. 1339–1341, 1898.)—The kathode radiation is fed by a supply of positively charged matter coming from the various parts of the vacuum-tube. The greater part of this current arrives in the central region of the kathode, owing to the repulsion of the walls. Hence the existence of a central kathode beam. The positive influx is visible near the kathode, towards which it converges. It is deflected by an electric field. The stopping of the positive influx at the kathode leads to the evolution of heat. When the kathode is perforated, a portion of the positive particles traverses the perforations, and we have Goldstein's canal-rays. E. E. F.

1049. *Magnetic and Electrostatic Deflection of Kathode Rays.* **W. Kaufmann.** (Annal. Phys. Chem. 65. 2. pp. 431–439, 1898.)—The magnetic deflection of kathode rays is inversely proportional to the square root of the difference of potential between anode and kathode. If V_0 is this difference, and J the intensity of the magnetising current, then the deflection is

$$y_0 = cJ/\sqrt{V_0},$$

provided it is small, and the potential is that of the anode, except in close proximity to the kathode, as is usually the case in ordinary tubes. But if a different potential obtains along any distance along the direction of propagation, and is superimposed upon a magnetic field there, the deflection is

$$y_0 = CJ/\sqrt{V'},$$

where V′ is the difference of potential between the length considered and the kathode, and C is a constant as before. The difference of potential between the anode and kathode therefore no longer influences the deflection. The above are results derived from the emission theory, and from the assumption that ϵ/m is constant. By allowing kathode rays to traverse a nearly closed space containing an electrostatic and a magnetic field, the author verifies the above formula, within the error caused by the dispersion of the magnetic lines of force. He makes out the ratio ϵ/m to be $1\cdot86 \times 10^7$ C.G.S. units per gramme. E. E. F.

1050. *Refractive Index of Glass for Electric Waves.* **J. C. Bose.** (Roy. Soc. Proc. 42. pp. 293–300, 1898.)—The author uses waves of a frequency of the order 10^{10}, and describes four methods of determination which, with their results, are as follows:—

(1) Total internal reflection from a single semi-cylinder, $\mu=2\cdot08$
(2) „ „ two semi-cylinders, $\mu=2\cdot04$
(3) Refraction from glass into air, $\mu=2\cdot04$
(4) „ air into glass, $\mu=2\cdot03$

The value of the optical index of the glass determined by the total-reflection method was found to be $\mu_D=1\cdot53$. E. H. B.

1051. *Total Reflection of Electric Radiation.* **J. C. Bose.** (Roy. Soc. Proc. 62. pp. 300–310, 1898.)—A right-angled prism of glass receives electric radiation normally on one face so as to give total internal reflection from the hypothenuse face. A second prism like the first is then placed so that the hypothenuse-faces of the two prisms are parallel, an air-space intervening between them. Then, as the thickness of this air-space is diminished a critical value is found below which total internal reflection no longer obtains. This minimum thickness for total reflection varies with the angle of incidence and wave-length of the radiation, and in the cases given ranged between 13 and 5 mm. E. H. B.

1052. *Rotatory Polarisation of Electric Waves.* **J. C. Bose.** (Roy. Soc. Proc. 63. pp. 146–152, 1898.)—The author passes electric radiation through a polariser and an analyser, each of book-form as previously described by him (Roy. Soc. Proc. vol. 60). When polariser and analyser are crossed, the field is completely extinguished. On the interposition of a bundle of parallel jute-fibres 10 cm. long and 4·5 cm. diam., with the axis of the bundle parallel to the direction of the radiation, no effect is produced. When, however, the bundle is twisted and again interposed, the field is restored. It appeared, therefore, that a rotation of the plane of polarisation had occurred. To imitate the rotation produced by sugar solutions a number of small bundles of twisted jute-fibres were prepared, the twist of some being right-handed and of others left-handed. The interposition of a number of either variety alone in the extinguished field restored the passage of radiation through the crossed polariser and analyser. But a number of the right-handed variety interposed together with an equal number of precisely similar left-handed bundles produced no effect on the field. E. H. B.

1053. *Electric Waves.* **C. Gutton.** (Comptes Rendus, 126. pp. 1092–1095, 1898.)—This note describes a case in which an electric wave proceeding along a wire may pass without change of phase to a second wire not in contact with the first. The two wires are in the same straight line, and the end of one is provided with a tube which encircles, without touching, the end of the other. E. H. B.

1054. *Universal Shunt.* **J. Rymer-Jones.** (Elect. Rev. 42. pp. 717–718, 1898.)—The author, in view of the incorrect opinion that Kelvin-Varley slides are not applicable as a universal shunt, gives calculations showing that the scale-reading is proportional to the multiplying power of the shunt. He then describes a simplified form of Kelvin-Varley slides, in which the 100-vernier coils are fixed to a movable ebonite disc, to which also are fixed the springs making contact with the main resistances. For the rough adjustment the whole disc is moved round, and the same handle serves, on loosening a detent, for the fine adjustment with the vernier coils. G. H. Ba.

1055. *Diffusion and Conductivity of Gases.* **J. S. Townsend.** (Phil. Mag. 45. pp. 469–480, 1898.)—In this paper it is shown that some well-known phenomena connected with conducting gases may be explained by diffusion. The paper is divided into two sections, the first of which contains the solutions of some problems which apply not only to conducting gases, but also to gases in general. The question which is dealt with may be stated thus:—If there are two gases A and B contained inside a vessel the walls of which absorb A, what quality of A will remain unabsorbed and be left distributed throughout B after a given time has elapsed?

The following are the solutions of this problem for three particular forms of boundary: q_0 being the quantity of A in the vessel initially, the distribution of which is supposed to be uniform; q_t the quantity of A unabsorbed after a time t; κ the coefficient of diffusion of A into B.

1. When the boundary is a pair of parallel planes at a distance a apart,

$$q = q_0 \frac{8}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\epsilon^{\frac{-(2n-1)^2\pi^2\kappa t}{a^2}}}{(2n-1)^2}.$$

2. When the boundary is a cylinder of radius a,

$$q_t=q_0\,4\left[\frac{\epsilon^{-\alpha_1{}^2\kappa t}}{a^2\alpha_2^2}+\frac{\epsilon^{-\alpha_2{}^2\kappa t}}{a^2\alpha_2^2}+\&c.\right],$$

where $a\alpha_1$, $a\alpha_2$, etc. are the roots of Bessel's function $J_0(x)$.

3. When the boundary is a sphere of radius a,

$$q_t=q_0\,\frac{6}{\pi^2}\sum_{n=1}^{n=\infty}\frac{\epsilon^{-\frac{\pi^2n^2}{a^2}\kappa t}}{x^2}.$$

By means of the last equation a rough estimate could be made of the amount of impurity A that would be removed from a gas B by bubbling through a liquid which absorbed A. The solution shows that this amount depends on the rate of diffusion of A through B, and that in order to reduce the quantity of A to a given fraction the time the bubble takes to rise in the liquid must be proportional to the square of its radius.

The second section deals with the applications of these results to conducting gases. When the ion, or carrier of the electric charge, comes into contact with a conductor, it either gives up its charge, or remains in contact with the conductor held attracted to the surface by the electric force arising from its image. The surface of a conductor, therefore, acts like a perfect absorber of the charges on the carriers, so that a gas loses its conductivity owing to the ions coming into contact with the sides of the vessel which contains it.

If the charged carriers be considered as constituting the gas A and the rest of the molecules as the gas B, the solutions of the problems in Section I. can be applied to conducting gases if we give to q_0, q_t, κ the following definitions:—

q_0 the conductivity [or number of charged carriers in B] initially;
q_t the conductivity at the time t;
κ the coefficient of diffusion of the carriers into the gas B.

The loss of conductivity of the gas due to the encounters between positive and negative carriers being neglected.

A simple consideration of the equations of motion of the gas gives a method of finding κ.

Let e denote the charge on the carrier; u, v, w, the velocities of A parallel to the axes; p the pressure of A; n the number of carriers per c.c.; x y z the electric forces at any point.

The equations of motion of A are of the form

$$Xe=\frac{1}{n}\frac{dp}{dx}+\alpha u.$$

If X is large, so that $\frac{1}{n}\frac{dp}{dx}$ may be neglected in comparison with Xe, then $\alpha u=Xe$. Let V be the velocity of the carrier when acted on by a force of 1 volt per centimetre, which is $\frac{1}{300}$ in electrostatic units, and we obtain $a=\frac{e}{200\mathrm{V}}$, so that when there are no electric forces acting on the gas the motion is given by three equations of the form :

$$\frac{1}{n}\frac{dp}{dx}+\frac{eu}{300\mathrm{V}}=0,$$

or

$$-pu=\frac{300\mathrm{PV}}{\mathrm{N}e}\frac{dp}{dx},$$

where N is the number of molecules in a gas at the temperature (about 15° Centigrade) at which the diffusion takes place, and at a pressure P, 760 mm.

This last form of the equation of motion shows that κ is $\frac{300\mathrm{PV}}{\mathrm{N}e}$. If the charge e be taken as the same as the charge on an atom of oxygen in electrolysis, we have $1{\cdot}2\mathrm{N}e=\frac{3}{2}10^{10}$, since one electromagnetic unit of electricity, or 3.10^{10} electrostatic units, gives off from an electrolyte ·6 c.c. of oxgen. When dealing with air which has been made a conductor by Röntgen rays, $\mathrm{V}=1{\cdot}6$ centimetres per second, so that $\mathrm{K}={\cdot}038$.

Using this value of κ in the formulæ given in Section I., the loss of conductivity of Röntgenized air due to bubbling through liquids or passing through tubes will be found. For example air, passing along tubing 10 centimetres long and 1 millimetre radius at the rate of 100 centimetres a second, would have its conductivity reduced to $\frac{1}{13}$th of its original value. This fraction can only be taken as roughly approximate, as the motion of a gas along a tube is not uniform across the section; the velocity being greater at the centre than at the sides, would have the effect of diminishing the number of carriers that would come into contact with the surface of the tube.

It will be observed that this theory shows that the loss of conductivity will be increased by reducing the size of the carrier, since the coefficient of diffusion κ would then be increased. This result agrees with the result of experiment, as there are several examples of conducting gases which can be passed through fine tubing, or a plug of glass wool, without losing much of the charge; and it has been found that, when acted upon by an electromotive force, the carriers move much slower than the carriers in a gas made a conductor by Röntgen rays.

It can therefore be concluded that when a gas retains its conductivity after passing through wool or bubbling through liquids, that the carriers are too large to diffuse rapidly, and are small compared with the apertures through which the gas passes.

AUTHOR.

1056. *Conductivity of Gases.* **R. W. Wood.** (Phys. Rev. 6. pp. 165–166, 1898.)—A compact apparatus of the kind devised by Kuntz is described, for showing the conductivity of gases. A larger bulb containing the gas to be tested (or a vacuum) surrounds a smaller bulb containing ether and communicating with a nozzle. On immersion in boiling water the ether is more or less rapidly evaporated according to the conductivity of the intervening gas, and the vapour will burn at the nozzle in a jet of corresponding height. The bad conductivity of a vacuum is well shown. Glass-working directions are given. A. D.

1057. *Determination of Thermal and Electric Conductivities.* **P. Straneo.** (Roma, R. Accad. Lincei, Atti, 7. pp. 197–202, 1898.)—A mathematical paper showing how it is possible, by simultaneous observations, to ascertain both the thermic and the electric conductivities of a wire at high temperatures. The errors due to slight mismeasurements of the points at which certain stationary temperatures are observed is very small. A. D.

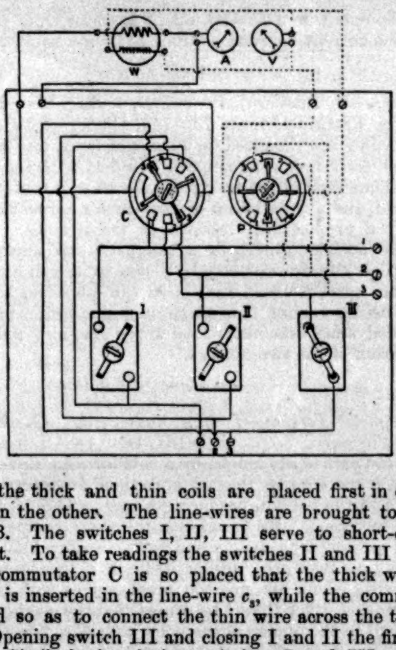
1058. *Dielectric Constant of Ice.* **R. Abegg.** (Annal. Phys. Chem. 65. 1. pp. 229–236, 1898.)—The author attributes the varying values of the dielectric constant of ice obtained by Dewar and Fleming, not to electric dispersion, nor, as he previously suggested, to electrolytic polarisation, but to residual conducting-canals within the substance of the ice, either unfrozen or formed by chains of conducting electrolytes remaining after purification. E. E. F.

1059. *Cadmium Standard Cell.* **P. Kohnstamm** and **E. Cohen.** (Annal. Phys. Chem. 65. 2. pp. 344–357, 1898.)—The Weston cadmium cell shows an irregularity in the temperature coefficient below 5° which renders its use in the cold less satisfactory. The authors investigate the cause of the irregularity and discover it in the fact that the curve of solubility of the cadmium sulphate undergoes a sudden change at 15°, remaining stationary between that temperature and 20°. This is no doubt due to some change in the constitution of the salt, which under ordinary circumstances corresponds to the formula $CdSO_4 . \frac{8}{3}H_2O$. This change is analogous to the change of crystalline form undergone by sulphur at 95°. The Weston cell should only be used at temperatures above 15°. It then is much more stable than the Clark cell. E. E. F.

1060. *Tri-phase Power Measurements.* **M. Aliamet.** (Électricien, 15. pp. 243–246, 1898.)—The author shows that the power given to a tri-phase circuit can be measured by two wattmeter readings, viz.: it is given by

$$P = p_{13}c_3 + p_{12}c_2,$$

where c_2, c_3 are respectively the currents in the second and third wires, and p_{13}, p_{12} the differences of potential between the first and third, and the first and second wires respectively. He then goes on to describe a single wattmeter by which both these readings may be taken in quick succession. It is shown diagrammatically in the accompanying figure. C and P are commutators, by means of which the thick and thin coils are placed first in one circuit and then in the other. The line-wires are brought to terminals 1, 2, and 3. The switches I, II, III serve to short-circuit the instrument. To take readings the switches II and III are closed, and the commutator C is so placed that the thick wire of the wattmeter is inserted in the line-wire c_3, while the commutator P is arranged so as to connect the thin wire across the terminals 1 and 3. Opening switch III and closing I and II the first reading is taken. Similarly, by closing switches I and III, opening II, and changing the commutators C and P, the second reading is taken. W. G. R.



1061. *Magnet Poles.* **G. Schürr.** (Journ. de Physique, 7. pp. 282-285, 1898.)—When a current acts on a magnet, the points of application of the resultant of the action due to each element must not be confounded with the magnetic poles. The author puts an infinite horizontal current in the magnetic meridian at a distance b from a magnet movable round a vertical axis, as in Oersted's experiment, and arrives at the following conclusions:—Let 2 L represent the actual length of the magnet, 2 X the distance between the poles due to the current, $2l$ between the poles due to the earth's magnetism, whose horizontal component is H. A cylindrical needle of 110 mm. length and 2 mm. diameter of tempered steel magnetised to saturation, the current has a value 0·43 amperes, and b is varied from 16·2 cms. to 25·5 cms.

$$2X/2l \text{ varies from } 0{\cdot}6 \text{ to } 0{\cdot}7.$$

Thus in the case where $2l = 80$ mm., $2X$ varies from 48 mm. to 56 mm. as the current approaches from 25·5 cms. to 16·2 cms.
E. C. R.

1062. *Magnetic Intensity Variometer.* **A. Heydweiller.** (Annal. Phys. Chem. 64. 4. pp. 735–741, 1898.)—Two equal declination needles are mounted on a common axis, one above the other, so that each makes an angle of 45 deg. with the magnetic meridian. Thus each of the four poles moves in a nearly uniform magnetic field, and any variation of the earth's horizontal force is indicated by a proportional rotation of the needles. On this principle the author constructs a magnetic variometer. Two rhombic needles vibrate over copper plates in a cylindrical case. Their distance apart is about 6 cm., and can be adjusted at will. The lower needle carries two aluminium pointers, which travel over a divided scale attached to the upper one, and indicate the relative rotation of the two needles.
E. E. F.

1063. *Magnetic Torsion of Iron and Steel.* **G. Moreau.** (Journ. de Physique, 7. pp. 125–131, 1898.)—An iron wire is surrounded for part of its length by a bobbin. As discovered by Wiedemann, if the wire be twisted and then an electric current be sent through the bobbin, producing a magnetic field, the angle of twist is increased. By imagining the wire composed of an infinitude of elementary magnets, and finding an expression for the couples acting on them, the author deduces a theory, which, for fields and twists which are not too great, agrees with his experiments. Amongst other things he proves that the magnetic torsion is proportional to the torsion at the point considered, to the square of the intensity of the field (if it is weak), and that it is independent of the diameter of the wire.
A. Gs.

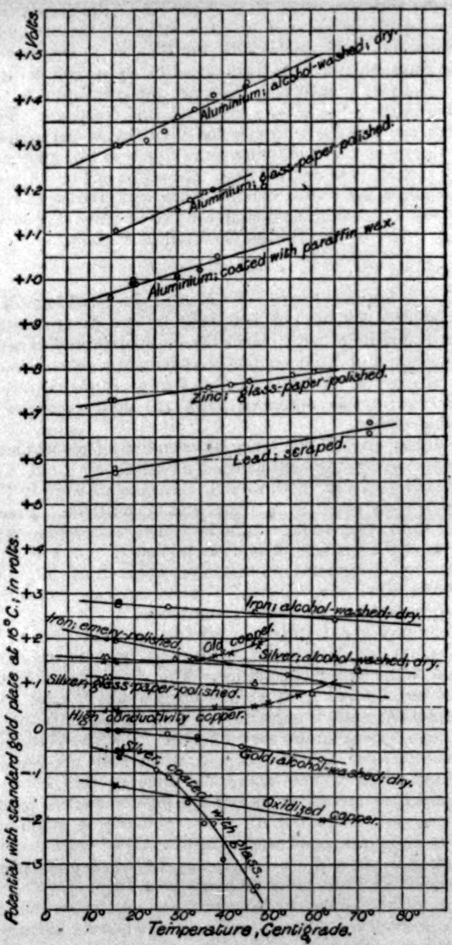
1064. *Magnetisation of Solid and Hollow Rings.* **F. Kirstädter.** (Annal. Phys. Chem. 65. 1. pp. 72–85, 1898.)—A ring, about 17·3 cm. external and 11·3 internal diameter (*i. e.* width of section about 3 cm.) is turned from an iron plate, and cut equatorially; each half is provided with a groove which is subsequently widened, and finally a solid ring is fitted into the hollow. Thus were obtained a solid ring, two half rings, three hollow rings of different thickness, and an inner solid ring, which were tested singly; the smallest and the inner ring were also combined. The rings were annealed for 24 hours in a charcoal fire and further subjected, in each case, to about a hundred cycles of magnetisation, in order to arrive at a permanent magnetic state. One layer of primary wire was coiled all over the ring; the secondary winding over this layer covered about a third of the circumference. Determinations were made with the help of a Du Bois-Rubens ballistic galvanometer; the field varied between 0·02 and 68 C.G.S. units. The very regular curves do not demonstrate any magnetic screening in the sense of von Feilitzsch and Grotrian. The magnetisation curve of the solid ring lies below that of the solid half and hollow rings whose curves follow more closely to one another in the order of their decreasing thickness. The action of Foucault currents, which would affect measurements made with the solid ring more than those of the split rings and the hollow rings still less, would probably suffice to explain the observed differences. H. B.

1065. *Contact Electricity of Metals.* **J. Erskine-Murray.** (Roy. Soc. Proc. 63. pp. 113–146, 1898.)—This experimental investigation had as its primary object the elucidation and measurement of the variation of Volta contact electricity of a pair of conductors, due to changes in the state of *that portion of the surface of each conductor which was separated from the other conductor by an insulating medium.*

The Volta-potential difference between two metals was measured, usually in air, by the null method described by Lord Kelvin in the B. A. Report for 1880, p. 494. The metals were in the form of circular discs, about 9 cm. diam. and ·2 cm. thick. Precautions were taken in order to determine as exactly as possible the actual condition of the surfaces in every experiment. On account of the large variety of experiments described, it has been found difficult to make a satisfactory abstract; what, appear, however, to be the most important results are given below.

(*a*) Metals covered with non-conducting solid films of wax or glass, except at their point of contact, give nearly the same potential as the bare metals in air. The substitute of wax for air next the metal only causes a small change which may be in the same direction and of approximately equal amounts for metals whose potentials in air are very different; *e.g.*, the Volta-potential difference between zinc and copper when both are coated with solid paraffin wax is very nearly the same as that between bare zinc and copper, and is also nearly the same as that of bare copper and waxed zinc, or *v. v.*, in air. The potential of sodium, coated with wax and glass, was found to be about 3·56 volts positive to a standard gold plate of electrolytically deposited gold, which had been washed with alcohol some hours previously.

(*b*) A metal cleaned by careful polishing or scratching with emery-cloth or glass-paper is less positive when its surface is in a sharply scratched condition than when smooth or burnished, the difference frequently amounting to 0·2 or 0·3 of a volt. The change being probably caused by a hardening of the surface-layers. The author points out that this result is not in opposition to



Pellat's*, for the conditions were different, as Pellat's plates were washed with alcohol after polishing.

(c) The temperature variations, between 15° C. and 60° C., of the Volta-potential of many metals have been determined, both for clean dry metals in air and for metals coated with liquid or non-conducting solid films; and it has been found that they are of considerable magnitude in both cases. The curves representing the variation of potential with temperature appear as if they should meet at a point below −200° C., at a potential about 0·4 volt positive to a standard gold plate at 16° C.; this suggests that Volta-potential differences may possibly vanish at a very low temperature.

(d) A liquid film, even if of extreme thinness, may cause a considerable change in the potential of a dry polished plate, which continues permanent for many hours and even days after the disappearance of the film. The results of many experiments made with alcohol and other liquids on gold, silver, zinc, copper, iron, tin, lead, and aluminium are given. It is noted that in almost every case the contact-potential of a metal which has been polished on a hardly dry material rises at least 0·15 volt in consequence of alcohol washing, and that this change is nearly permanent for many hours after the plate appears to be quite dry.

Two films of the same liquid opposed to one another on the surfaces of two plates of different metals do not usually give zero potential-difference, as solid conducting films of one material would do, but give nearly the same potential-difference as the dry metals on which they lie.

(e) A very thin film of oxide on a metal produces only a very small change in the potential, and every increase in thickness of the film is attended by a further change in potential until a limiting value is reached, which is that of a mass of the oxide.

(f) Exposure to the atmosphere at ordinary temperatures does not, as a rule, produce any rapid change in Volta-potential, especially if the air be comparatively dry and free from dust. The ultimate change is usually in the negative direction.

(g) Experiments were made to find the result of immersing a metal in a gas other than air, as in Lord Kelvin's experiments (Nature, 1881). One plate only was immersed in the gas for a short period, in some cases of only a few minutes, in others as long as 45 minutes, its potential with a standard plate being measured, in air, before and after immersion in the gas. This method gives the variation of potential, relative to the fixed standard, due to temporary alteration of the surface-film on the plate. Immersion in oxygen caused copper, zinc, and silver to become temporarily positive, while tin and platinum became negative. The potentials returned to very nearly their original values a few hours after the plates were taken out of the oxygen bath. AUTHOR.

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* Ann. de Phys. et de Chimie, 1881.

1066. *On the Theory of Magneto-Optic Phenomena.* **C. H. Wind.** (Phys. Rev. 6. pp. 98–113, 1898.)—Having previously obtained various equations (see Abstract No. 504), the author proceeds to consider the case of light incident on an interface of two media, one of which is conducting, in a field of given external magnetic force. The incident ray being plane-polarised, he assumes that the refracted light in the conducting medium will consist of two rays circularly polarised in opposite directions, and the problem is considered what must be the constitution of the incident light in order that the refracted ray may be polarised in a given manner. In order to solve this, he deals first with the reflected ray, and finds that as a consequence of the magnetic force, there will be, in addition to the ordinary reflected ray, which is polarised in the same plane as the incident light, another component polarised in a plane at right angles to this last. This he calls the magneto-optic component. It constitutes the phenomenon known as the Kerr effect. It can be derived from equation C of the former abstract, p being a complex constant. In this relation he compares his results with those of Van Loghem, Sissingh, and Zeeman.

It has been asserted by some writers that if the magnetic force be perpendicular to the plane of incidence, no magneto-optic effect is to be expected. But the theory indicates that an optical effect of another kind will be produced, namely, a change in the quantities known as the "phase difference ϕ, and the re-established azimuth h." And he refers to Zeeman as having observed this effect.

Drude's theory is then discussed. It differs from that of Wind only in using a real instead of a complex quantity for the magneto-optic constant. Drude's theory, and also Goldhammer's, are based on Maxwell's division of the electric current into a conduction and a displacement current, a hypothesis which is not introduced by Wind.

Then is enunciated as axiomatic the following "principle of symmetry":—*If any system can be considered as its own reflected image, not only as regards the position of the material points of the system, but also as regards the laws of their mutual action, then corresponding to every possible state of motion of the system, there is another state which behaves towards the first as its reflected image.* From this assumed principle he deduces the effect of magnetisation on the reflected light.

Then is proposed an explanation of the complex nature of the Hall constant (equation C). Drude's theory, in which the Hall constant is real, corresponds to the assumption that no Hall effect is to be attributed to the conduction-current.

It is shown that all the author's equations A, B, and I. . . VI. are deducible from Lorenz' theory of the motion of electricity by ions. The remaining equation C of the author's theory is to be obtained by assuming that the velocity of the cations is not precisely the same as that of the anions, as has been suggested before.

S. H. B.

1067. *Apparent Electrification in an Electric Field at the Bounding Surface of two Dielectrics.* **A. Anderson.** (Cambridge Phil. Soc. Proceedings, 9. 6. pp. 292–294, 1897.)—The two dielectrics, having inductive capacities K_1, K_2, are separated by a surface S. If there be no real surface distribution on S, there is discontinuity of the normal electric forces owing to the variation of K; and σ' is the density of that distribution on S, which in a hypothetical case where K_1 and K_2 are both unity, *cæteris paribus*, would produce the given discontinuity of force. Maxwell calls σ' the apparent electrification. Now Maxwell says that if the apparent electrification be discharged "by passing a flame over" S, then when the inducing force is taken away there remains on S a true distribution of opposite sign to σ'. And this is described in an appendix to Maxwell's chapter as the result of the conducting flame being connected with the earth. According to Gray ('Absolute Measurements in Electricity and Magnetism') the action of the flame reduces S to *zero potential.* According to Mascart and Joubert it reduces S to *the neutral state*, and when the sources of induction are removed, there remains on S a real layer of density the same as the fictive layer, or apparent electrification.

According to Wiedemann (Die Lehre von Electricität, Band II.) the flame removes the apparent electrification, and produces a real electrification of opposite sign, *depending on the action of the apparent electrification in the interior of the body.*

Professor Anderson shows by an example that even if the flame reduces S to zero potential, the real distribution so produced is not necessarily of the opposite sign to σ'. His view is as follows: Let σ_1 be that distribution on S which in the actual case (K varying) would make the normal force continuous. Then the effect of discharging the apparent electrification is to produce on S the distribution σ_1. Now zero in the actual case corresponds to σ' in the hypothetical case, and σ_1 in the actual case corresponds to zero or $\sigma' - \sigma'$ in the hypothetical case, so that the action of the flame produces on S_1, not $-\sigma'$, but a distribution σ_1, which is equivalent to the apparent electrification $-\sigma'$. S. H. B.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1068. *Fifth Annual Report of the Committee on Atomic Weights.* **F. W. Clarke.** (Chem. News, 77. pp. 239–242, 1898.)—Papers published during 1897 which bear on atomic weights are critically reviewed. The papers considered refer to the atomic weights of carbon, nitrogen, chlorine, silver, aluminium, nickel, cobalt, tungsten, and cerium. A complete list of atomic weights is given which differs from that published in 1896 in the following instances:—carbon = 12·00, cerium = 139·35, cobalt = 58·99, when O = 16. Rummel (Proc. Roy. Soc. of Victoria (Australia) x. pt. 1, p. 75) has worked out relationships between the spectra of the alkali metals and their atomic weights, from which the latter may be calculated with fair accuracy. T. E.

1069. *Liquefaction of Hydrogen and Helium.* **J. Dewar.** (Comptes Rendus, 126. pp. 1408–1412, 1898.)—Hydrogen cooled to −205° and under a pressure of 180 atmospheres is allowed to escape rapidly through a coil of tube into a vacuum vessel, doubly silvered and surrounded by a vacuous space maintained below −200° C. About 1 °/₀ of the gas is obtained in the form of a clear colourless liquid showing no absorption spectrum, and with a well-defined meniscus and apparently high refraction and dispersion. A glass tube closed at one end plunged into it becomes filled with solid air. Helium is similarly condensed to a liquid. T. E.

1070. *Equilibrium in the Ternary System; Lead, Tin, Bismuth.* **G. Charpy.** (Comptes Rendus, 126. pp. 1569–1573, 1898.)—Lead, tin, and bismuth are miscible in all proportions, at suitable temperatures, and form neither compounds nor isomorphous mixtures with each other. In mixtures containing these metals one liquid phase and three solid phases (consisting of the three pure metals) are therefore alone possible. The author has determined the freezing-points and compositions of 56 alloys of the three metals, and represents the results by means of the usual equilateral triangular diagram. The ternary eutectic alloy contains about 32 per cent. of lead, 16 per cent. of tin, and 52 per cent. of bismuth, and melts at 96°. T. E.

1071. *Microstructure of Nickel and Iron Alloys.* **F. Osmond.** (Comptes Rendus, 126. pp. 1352–1354, 1898.)—Alloys containing up to 8 per cent. of nickel have a structure resembling that of ordinary steel, the granulation being however somewhat finer. Alloys containing 12 to 25 per cent. of nickel show (on a polished and etched surface) fibrous rectilinear bundles, the orientation of which is parallel to three main directions. The characteristics of this group are, except in minor details, those of hardened steels. The non-magnetic alloys containing about 25 per cent. of nickel and those which contain 30 to 80 per cent. of nickel (and are magnetic owing to this excess of nickel) form a third group, having a purely crystalline structure. After etching, these alloys are seen to be full of small pin-holes. This classification is identical with that based on the mechanical properties of the alloys. T. E.

1072. *Electromotive Properties of Chromium.* **W. Hittorf.** (Annal. Phys. Chem. 65. 2. pp. 320–343, 1898.)—The position of chromium in the electromotive series depends upon its chemical state. Fresh fractures of the metal are in an active state, corresponding to the oxide CrO_3, and in that state the metal stands immediately above zinc, and precipitates other metals from their solutions. In the inactive state, corresponding to the oxide CrO, it is a noble metal, reduces no other metal from its salt solutions, and stands at the electro-negative end of the series next to platinum. Experiments with a large number of different electrodes and electrolytes show that chromium as an anode may, with the same electrolyte, assume each of its three grades, according to the solvent and the temperature. By modern processes the metal can be obtained in large quantities, completely fused and free from carbon. E. E. F.

1073. *Solid Solutions of Organic Compounds.* **G. Bruni.** (Roma, R. Accad. Lincei, Atti, 7. pp. 166–171, 1898.)—The author describes a series of experiments made in order to discover what similarity of constitution between two compounds determines the formation of a solid solution, and the consequent abnormal cryoscopic behaviour of the substances. The results hitherto obtained refer chiefly to closed chain compounds, and it has been found that solid solutions are produced from two compounds which differ in composition by two atoms of hydrogen, such as naphthalene and its dihydride. This rule, however, does not hold good for open-chain compounds, since solutions of oleic acid, stearic acid, and of butyric acid in crotonic acid, exhibit the normal cryoscopic depression. In explanation of these facts it is urged that the formation or disruption of a double bond must cause a much greater alteration in the molecular symmetry of an open chain than in that of a closed chain compound. Examples of the formation of solid solutions in the case of open-chain derivatives must, therefore, be sought among compounds of identical molecular configuration, such as carbon tetrachloride and tetrabromide, trichloracetamide and tribromacetamide, the behaviour of which has already been investigated by other observers. The present paper gives the results of experiments made with solutions of chloroform and iodoform in bromoform, and of ethylene chloride and iodide in ethylene bromide. In each case the formation of a solid solution is indicated by cryoscopic determinations at various concentrations, and this is confirmed, in the case of iodoform dissolved in bromoform, by analyses of the separated crystalline mass and of the mother liquor. Theoretical considerations, based upon a comparison of the melting-points of the above-mentioned compounds, lead to the supposition that the abnormalities will be much more pronounced in the case of the iodine than in that of the chlorine derivatives. and this is in complete harmony with the facts observed. J. W.

1074. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 14. pp. 106–109, 1898.)—The writer gives the methods of various authors for the separation of a number of metals. W. R. C.

1075. *Electro-deposition of Metals.* **J. C. Graham.** (Elect. Rev. 42. pp. 278–279, 319–320, 357–358, & 458–460, 1898.)—In this paper, which was communicated to the Royal Society, the author gives an account of experiments carried out chiefly with regard to the deposition of copper. Molecular motion does very little to compensate for the dilution caused by the deposition at the kathode, and therefore copper cannot be satisfactorily deposited if the current-density at the kathode much exceeds 300 amperes per square metre. But the current-density may reach ten times this value if the electrolyte is given a very rapid circulation, and the kathode also shielded about the edges to prevent the formation of trees. In the case of copper anodes the current-density is found to fall very rapidly from its initial value (when high), but this does not occur if lead is used as an anode. If there is a rapid circulation this drop does not take place. The pressure between the electrodes also varies abnormally unless the electrolyte is in circulation. The author concludes with examples of the deposition of copper from impure solutions. The colour of the deposit is brown if the solution includes much chloride. W. R. C.

1076. *Polarisation and Electrolysis.* **M. Del Proposto.** (Bull. Ass. Ing. El., Liège, 9. pp. 36–57, 1897.)—The author has investigated certain discrepancies which are found to occur between the observed electromotive force of polarisation and the value determined by Kelvin's law, for various solutions. He describes some experiments in which the terminal potential difference and the polarisation E.M.F. were measured for gradually-increasing currents, and obtained curves similar to curves of magnetisation, *i. e.*, two substantially straight lines connected by a curve. From this the author draws the following deductions, viz.:—Assuming that the two ions of the electrolytic molecule are charged with electricity of opposite sign so as to form a kind of elementary electromagnet, then, under the action of the electric force, the small magnets will be turned with their similar poles to the same sides, and the electrolyte will form a kind of magnet which only presents free masses (? magnetism) at the surfaces in contact with the electrodes. The mean intensity of magnetisation, which corresponds to polarisation in condensers, will be equal to the mean density of electricity on the extreme faces of the electrolyte, and the intensity of the current corresponds to the intensity of the field in the phenomena of magnetisation.

The author also investigated the effect of introducing diaphragms of glass and metal into the liquid between the electrodes, the diaphragms extending to various depths in the liquid. He found that the increase of potential difference for a given current passing through the voltameter follows approximately the same law as the fall of pressure produced by throttling a water-conduit. The author also discusses the "secondary electrolysis" which is set up when the diaphragm is made of conducting material. C. K. F.

1077. *Secondary Electrolysis.* **E. Andréoli.** (Ind. Électrochim. 2. pp. 36–38, 1898; also Génie Civil, 9. t. 27, 29 June, 1895.)—If an electrolytic cell be divided into three compartments by means of porous partition-walls, and be filled with the same electrolyte, a current passed through it by means of electrodes in the two outer compartments does not produce any change in the central compartment of the cell. If, however, one or more insulated metal plates be immersed in the liquid in the latter, electrolytic decomposition occurs, and to this the author gives the name of "secondary electrolysis," and states that he is the discoverer of this phenomenon.

As examples of secondary electrolysis he gives the following:—

1. Deposition of gold from a gold-cyanide solution placed in the central compartment, lead plates being used to receive it. In the outer compartments solutions of sodium chloride are used with a gas-carbon anode, and an iron kathode.

2. Deposition of gold from gold-cyanide solution in central compartment.—The outer compartments were filled with the same solution of gold cyanide, but after many days no change could be detected in the gold contents of the liquid in these compartments.

3. Conversion of sodium bisulphite into hydrosulphite.—The side compartments in this case may contain any electrolyte; the central compartment is fed with a solution of the bisulphite, and only two metal plates are immersed in it. Bleaching operations can be effected by means of the liberated hydrosulphite.

The author considers that these observations and facts are in conflict with the modern theory of ionic transportation, and he closes his article with a request to electrochemists for criticisms and suggestions upon the subject. J. B. C. K.

1078. *Electrodes for Electrolysis of Alkali Metal Chlorides.* **H. Becker.** (Ind. Électrochim. 2. pp. 25–26, 1898.)—The materials generally used for electrodes to be employed in salt solutions containing chlorine are gas-carbon, or graphite with which ordinary coke is sometimes mixed to form a moulding compound. High density is one of the chief characteristics required of the product. Girard and Street and Castner convert ordinary carbon into graphite by heating it in closed boxes to the temperature of the electric arc. Other inventors have described electrodes of high resistance towards chlorine, made by moulding mixtures of powdered carbon and tar under pressure, and heating to 1000° C. The use of rough blocks of gas-carbon, made into one conducting medium in various ways, has been patented by many inventors. Others have suggested the use of metallic oxides—as, for example, Gerald and Falconer, peroxide of lead, and Blackman, magnetite or ilmenite.

Electrodes formed of an alloy of platinum and iridium are in actual use in several works producing bleach and chlorates. Platinum alone is not found sufficiently resistant to the chlorine; while platinised electrodes are still less satisfactory. The forms of the platinum-iridium electrodes are very diverse. In the chlorate works they are generally made by stretching thin sheets of the alloy over a wire frame of the same. Kellner has patented a form in which short platinum wires are embedded in an ebonite plate. Hoepfner has patented the use of ferro-silicium; but this was previously described by Uelsmann. Parker and Robinson have suggested chromium phosphide. As materials for kathodes, gas-carbon, iron, and nickel are in actual use. Fluid kathodes have been patented by several inventors: Castner and Kellner have used mercury, while Vautin and Hulin have used molten lead. Finally, Richardson and Holland, and Franchot and Gibbs have patented the use of copper oxide. Short descriptions of many of the above Patents are given. J. B. C. K.

1079. *Diaphragms for the Electrolysis of the Alkali Metal Chlorides.* **H. Becker.** (Ind. Électrochim. 2. pp. 33–34, 1898.) —Many materials for diaphragms have been proposed, but only few have received experimental trial. Parchment-paper has been suggested by Le Sueur, Kiliani, Rathenau and Sutter; it is in actual use at Rumford Falls, U.S.A., and at Bitterfeld in Germany. At Leopoldshall parchment protected by a coating of calcium or magnesium oxychloride is used in the electrolytic cells.

Rieckmann describes diaphragms of albuminised paper, or of albumen alone; while Hoepfner has suggested the use of paper or cardboard coated with collodion. Diaphragms of unglazed porcelain or baked clay have been patented by many, and are in actual use in three works. Asbestos as a material for diaphragms has been patented by Roberts and McGraw, Hargreaves and Bird, Riquelle, Wiernick, Waite, Hempel, Richardson, and by Lucius and Bruning. Porous partition walls of Portland cement have been patented by Breuer, Hurter, and by Carmichael. Brief descriptions of all the Patents named above are given by the author.

J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

1080. *Storage-Batteries in America.* **J. Wetzler.** (Elect. Engin. N. Y. 25. pp. 443–460, 1898.)—This is an illustrated account of the works of the Electric Storage Battery Co. of Philadelphia and of the processes involved in the manufacture of their storage-cells. Particulars are also given of some large batteries installed in central stations, tramway stations and lighting plants, and of their application in telephone exchanges, and for telegraphic purposes. The positive plates, "Manchester" type, consist of a grid of antimonious lead with coils of corrugated lead tape forced into the apertures under hydraulic pressure. The tape is corrugated, cut into lengths, and coiled by an automatic machine which does the same work as 40 to 50 boys. The negative plates are constructed of pellets or pastilles of cast lead chloride—hence the name "Chloride Accumulator"—held together by a frame of antimonious lead cast round them. They are then placed between sheets of zinc in an electrolyte of zinc chloride, and the pastilles reduced to a highly crystalline form of porous lead. Finally, they are subjected to several washings and constituted kathodes in an electrolytic bath for some hours to ensure the entire elimination of chlorine from the pastilles. Both the positive and negative grids are cast under a pressure of 100 lbs. per sq. in. E. J. W.

1081. *Variation of Capacity of Accumulators with Discharge Rate.* **J. Reyval.** (Écl. Électr. 15. pp. 143–146, 1898.)—W. Peukert found that the current I and time of discharge t are related by the formula

$$I^n t = k,$$

in which n and k are constants for any particular type of cells. The author gives an account of the results obtained by F. Loppé in verifying this law. A set of curves is given showing the marked variation of capacity. W. R. C.

1082. *Lead-Zinc and Cadmium Accumulators.* (Écl. Électr. 15. pp. 242–244, 1898.)—The use of zinc instead of lead for the anodes of accumulators (*e. g.* that of Regnier) offers the advantages of an increased E.M.F., and also, owing to diminished weight, of an increased specific capacity. Unfortunately, the zinc dissolves when the circuit is open, a defect which is very imperfectly remedied by amalgamation, and hence Commelin and Finot use cadmium instead. In the Werner accumulator the electrolyte is a solution of the mixed sulphates of zinc, cadmium, and magnesium. In charging, a coherent deposit of zinc and cadmium is obtained, which is practically unattacked when the circuit is open, the magnesium playing a little-understood but most important part.

It is found that if a concentrated solution of zinc sulphate is used alone a good deposit of zinc is produced, but the peroxidation of the kathode is feeble; whilst if cadmium sulphate be employed a good deposit and satisfactory peroxidation are obtained, but the E.M.F. falls off rapidly during the discharge. On the other hand, with dilute solutions of either salt, peroxidation is well effected, but a poor deposit is obtained. The addition of magnesium sulphate allows of the production of all the necessary conditions by means of solutions of moderate strength; nevertheless it is better to use more dilute solutions for rapid than for slow discharges. Some minor improvements are also made in the construction of the positive plates, with the object of bringing the active material into closer contact with the conducting support. The accumulator has a capacity of 82 watt-hours per kilogram of plates, or 36 watt-hours per kilogram of total weight, the current being 12–15 amperes. The E.M.F. is 2·4 volts at the commencement, and 1·9 volt at the end of the discharge. J. W.

1083. *Electrical Press-room.* (West. Electn. 22. pp. 221–222, 1898.)—This is an account of the motor-driven presses of the 'Chicago Record' and 'Daily News.' Each press is driven by two motors, one for driving purposes and a smaller slow-speed motor to manipulate the press in "making ready." An important feature of this installation is Mr. Stone's electro-pneumatic system of motor-control. Compressed air is used to operate the contact-arms of the rheostats, and at a number of convenient points on each press air-valves and push-buttons are located. The handle of an air-cock controls, through the specially constructed rheostat, the slow speed-motor, which is used in "dressing the press" or in making ready to run off an edition. This valve is constructed with three inlets and an exhaust, and can be set—first, to run the press slowly; second, to stop the press; or, third, to cause the air to go through a by-pass in such a manner that the press cannot be started from any other point. W. G. R.

1084. *Reiter's Speed-Regulator for Turbines.* (Écl. Électr. 15. pp. 290–293, 1898.)—An illustrated description of **H. Reiter's** electric brake for use as a speed-regulator in the case of turbines working under a small or moderate head of water—in which case a difficulty has always been experienced in maintaining a sufficiently constant speed with large variations of load. The device consists of a small centrifugal governor which, by raising or lowering a mercury vessel, alters the amount of resistance included in the circuit of the brake-electromagnet. The brake itself consists of a fixed central electro-magnet with re-curved pole-pieces, and an outer ring of steel or iron, which is driven by the turbine, and which absorbs more or less power by the eddycurrents induced in it, according to the degree of excitation of the magnet. The regulator is said to be much quicker in action than one in which a hydraulic brake is used. A. H.

1085. *Electric Governor for Marine Engine.* **E. Putato.** (Écl. Électr. 15. pp. 293–294, 1898.)—Two mercury-vessels attached to a longitudinal wall of the ship communicate with each other by means of a connecting-pipe. As the ship pitches, causing the propeller to rise either partially or wholly out of the water, mercury flows from one of the vessels into the other, the effect being to gradually short-circuit a set of resistances connected to contact-pins, which pass into the space above the mercury contained in the vessel nearer the bow of the ship. As these resistances are cut out, the current through one of a pair of electromagnets controlling the main steam-valve increases, and the valve is gradually closed. When the bow of the ship rises, the resistances are gradually inserted, and before the last pin rises above the mercury, an auxiliary electromagnet closes the circuit of the second large electromagnet controlling the valve, which is thereby opened. In the normal position of the vessel, no current passes through either electromagnet. A. H.

1086. *Morrison's Apparatus for Power Conversion.* (West. Electn. 22. pp. 277–278, 1898.)—The apparatus constitutes a variable speed-gear designed primarily for horseless carriages; the one in question weighs about 200 lbs., and is of 4 H.P. A gas or oil-engine runs at a constant speed of 600 revs. per minute, and is regulated by a centrifugal governor. To the shaft is fixed a cylinder carrying field-magnets. Mounted upon the shaft, but free to revolve upon it, is a Gamme ring-armature with commutator. When the vehicle is at rest the armature is stationary, and in starting, after the electric circuit is closed, the greatest current is generated. As the speed of the armature increases the energy exerted diminishes and the speed of the carriage increases. A. S.

1087. *Comparative Tests of Injectors.* **G. H. Trautmann.** (Mech. Eng. 1. p. 551, 1898.)—A digest of a series of tests of the performance of steam-injectors by nine different makers. A. S.

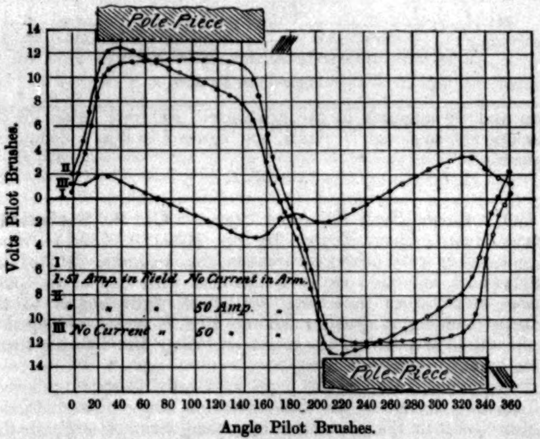
1088. *Belt Driving.* **J. Tullis.** (Mech. Eng. 1. pp. 452–454, and pp. 487–490, 1898.)—The author discusses the manufacture and care of leather belts for main-driving. High-speed belts running over 4000 ft. per minute should be made of single, pliable, tough thin leather; by compounding such belts, they may be run with advantage up to 9000 ft. per minute. Compound belt-driving is a simple and most trustworthy means of transmitting power without loss from slip. The cost of a narrow pulley is much less than that of a wide pulley; two 20-in. belts, working compound, will transmit more power than one 40-in. belt working from a wide pulley. The author gives a number of examples in which compound belt-driving has been applied with satisfactory results. To get perfect belt-driving a great deal depends on the form of the pulleys. Much loss of power and destruction of belting is due to the high convexity with which most pulleys are made. A convexity of $\frac{1}{16}$ of an inch is sufficient for pulleys 6 in. wide and under; the smaller or driven pulley may be made perfectly flat. The author discusses belt versus rope driving, and expresses his opinion strongly in favour of belts. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1089. *Standardising of Generators, Motors, and Transformers.* (Amer. Instit. Elect. Engin. 15. pp. 71–100, 1898.)—This is a discussion at the American Institution of Electrical Engineers on the advisability of having all dynamos, transformers, etc. of standard sizes so as to render pattern making less laborious and the manufacture of the machines cheaper. The question was referred to a select committee. W. G. R.

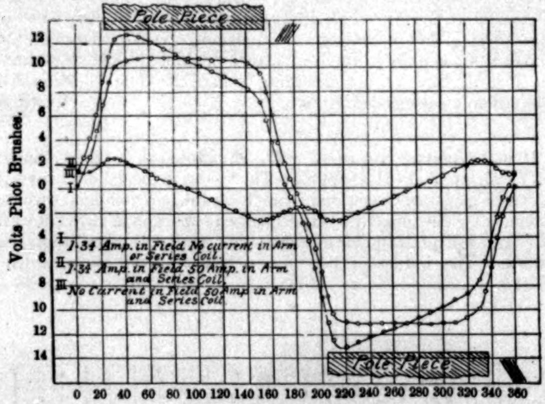
1090. *Armature Reactions.* **C. A. Bessey.** (Elect. Engin. N. Y. 25. pp. 511–512, 1898.)—This is an experimental investigation of armature reaction in simple shunt and compound wound dynamos. The machine experimented on was a 15 kilowatt, 125 volt Edison bi-polar dynamo run at 1600 revolutions per minute. The induction distribution was obtained by measuring with a Weston voltmeter the E.M.F. between two steel pilot brushes bearing on the commutator and shifted into different angular positions. Wirt collector brushes were used, and after being given proper lead for non-sparking at 50 amperes, were fixed in this position through the experiments.

Fig. 1.



In the accompanying figures, curves I shows the induction distribution with field excited and no current in the armature; curves II, the induction distribution with field excited and 50 amperes in the armature; curves III, field magnetism reduced to

Fig. 2.



zero and 50 amperes in the armature. Figure 1 refers to the machine run as a simple shunt, and figure 2 to it as a compound dynamo. W. G. R.

1091. *Single Phase Induction Motor.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin. 15. pp. 103–183, 1898.)—When running at or very near synchronism, the magnetic field of the single-phase induction motor is identical with that of the polyphase motor, since in a turn wound at right angles to the primary winding, at synchronism an E.M.F. is induced equal to that induced in a turn of the primary winding, but differing therefrom by 90° in phase.

The greater portion of this paper is devoted to starting devices. All starting devices of the commutatorless single-phase induction motor consist in the production of a component of magnetic flux displaced from the axis of polarisation of the induced currents, and may be grouped into three classes, viz.:—

1st. *Phase-splitting Devices*, in which the primary system is composed of two or more circuits displaced from each other in position, and combined with impedances of different inductance-factors so as to produce a phase-displacement between them.

2nd. *Induction Devices*, in which the motor is excited by a combination of two or more circuits which are in inductive relation to each other. This mutual induction between the motor circuits can either take place outside the motor in a separate phase-splitting device, or in the motor proper.

3rd. *Monocyclic Starting Device.*—An essentially wattless E.M.F. of displaced phase is produced outside of the motor, and used to energise a cross-magnetic circuit of the motor, either directly by a special tease-coil on the motor, or indirectly by combining this wattless E.M.F. with the main E.M.F., and thereby driving a system of E.M.F.'s of approximately three-phase or any other relation.

Each of these types of starting devices is discussed in detail, the object being to enquire into the starting torques and the acceleration produced. The author concludes that of all single-phase induction-motor starting devices, the monocyclic device most nearly reproduces in starting and accelerating the conditions of the polyphase motor. In the discussion which followed the reading of the paper, the question of the legitimacy of the assumption of sine currents and E.M.F.'s arose. The general opinion was that the results obtained on that assumption agreed so nearly with actual practice as to justify its use. W. G. R.

1092. *Asynchronous Motors.* **E. J. Brunswick.** (Électricien, 15. pp. 305–307, 321–324, and 340–344, 1898.)—The condition that the torque in a polyphase motor should be independent of the speed of the rotor is

$$R = pL;$$

where R is the resistance and L the coefficient of self-induction of each rotor circuit, and p is 2π times the frequency of the induced currents. From this it follows that a uniform torque could be obtained as the rotor runs up to speed by having variable resistances in the rotor circuits and gradually cutting them out as the speed increases. Such a process involves rubbing contacts and probability of sparking, both of which are undesirable. In the Boucherot system the same end is attained by different means. The stator, instead of being wound in the ordinary fashion, consists of two distinct windings, one of which is fixed and the other is capable of rotating through an angle representing half a period of the supply current. Thus in a four-pole motor the possible angular rotation is 90 degrees. The movable part of the stator assumes the displaced position at start, and is rotated back again on full speed being attained. The rotor is of special design, but still consists of short-circuited bars without any rubbing contacts whatever. Three types of motors are constructed according as the motor is to be placed in an accessible place or not, or in the case where the conditions require a minimum number of conductors.

W. G. R.

1093. *Thickness of Transformer-Plates.* **W. Dittenberger.** (Écl. Électr. 15. p. 362, 1898.)—Loppé has recently (Écl. Électr. 11. p. 548, 1897) given the following formula for the loss per cubic cm. of iron in the core of a transformer:

$$W = \alpha \frac{B'^{1\cdot6}(e+\epsilon)^{1\cdot6}}{e^{1\cdot6}} + \beta B'^{2}(e+\epsilon)^{2},$$

where e is thickness of plates, ϵ that of insulation between them, B' = magnetic flux per sq. cm. of section of core, and α and β are constants. Using this expression, Loppé graphically determines the value of e which will render B' a maximum for given values of W and ϵ. The author solves this problem analytically, and finds that the required value of e is given by the equation

$$W = \alpha \cdot \frac{\epsilon_4}{e^{12}} \left(\frac{4\alpha}{4\beta}\right)^{4} \cdot \left(1 + \frac{4}{5}\frac{\epsilon}{e}\right),$$

an approximate solution of which may be easily obtained. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1094. *Plant of the Ellicott Square Building.* **F. L. Wilson.** (Elect. World, 31. pp. 519–522, 1898.)—A feature of interest in the electrical plant of the Ellicott Building at Buffalo is the system of regulation of the forced draught. The system, due to Mr. John Beckman, depends upon the action of three valves. A regulating valve is placed on the inlet-pipe to the engine which drives the blower. This valve is so arranged as to open and increase the speed of the blower engine as the pressure of the steam in the boiler falls below the desired point, and to close and decrease the speed as the pressure rises. A pressure-reducing valve is placed in series with the regulating valve to limit the speed of the fan, and to set the draught pressure in such a manner as to produce the most efficient combustion and create under the boiler the greatest heat that the water is capable of absorbing. The stack damper is set to hold back this heat so that the escaping gases do not leave the uptake at more than 100° above the temperature of the steam. When the steam pressure in the boiler has reached the desired point the regulating valve cuts off the direct supply of steam to the blower engine, and the fan would stop but for the introduction of a by-pass consisting of a small pipe supplied with a reducing valve. By this means steam just sufficient to keep the fan revolving, and at a low pressure of 6 or 8 pounds, is supplied to the engine. The following results of tests on the working of the plant are worthy of notice :—

Water evaporated per pound of coal	6·77
Equivalent from and at 212°	8·18
Equivalent water per pound of combustible from and at 212°	9·03
Commercial horse-power of boilers, based on 30 pounds	250·00
Builder's rating	250·00
Average amount of steam supplied to electric-light engine per electric horse-power hour (pounds)	36·73
Average output for 8760 hours (365 days), kilowatts	77·99
Heaviest load, kilowatts	260·00
Average coal per ampere-hour, pounds (water supplied at 56°)	0·84
Average coal per ampere-hour (water supplied at 183°)	0·75

W. G. R.

1095. *High Voltage Transmission Lines.* **S. H. Dailey.** (Amer. Electn. 10. pp. 194–197, 1898.)—This is an article on the practical details to be noted in the erection of a high-voltage transmission line. Special attention is paid to safety devices, and the author recommends that a barb wire should run the entire length of the line and grounded every half mile. W. G. R.

1096. *Protection of Three-Wire System.* **E. Oxley.** (Elect. Engin. N.Y. 25. pp. 483–484, 1898.)—The author refers to the trouble which may be caused to that side of a three-wire system which has the smaller load due to a sudden and considerable increase in the potential reproduced upon that side, such increase being produced by opening the neutral, or balancing wire, by the blowing of its fuse. The increase in potential from this cause may reach a point where it is almost double the voltage that should normally exist. The injury to incandescent lamps, fan motors, and enclosed arc lamps may be considerable. The "over-fusing" of the neutral wire, which has come to be a common practice among wiremen and others, came into existence, and owes its prevalence to the fact that it has hitherto been the only known expedient for avoiding disturbances of this character. This practice of "over-fusing" the neutral wire is directly contrary to the rules of the Board of Fire Underwriters. The author points out that there is a far greater menace to property, however, in the fact that the abnormal tension on the underloaded side of the system, upon the blowing of the neutral fuse, develops weak spots in the wiring; or if such places already exist, the insulation quickly gives way under the strain, and destructive fires may be the direct result. To remove the possibility of such disturbances occurrng, the author has devised a simple safety attachment for a three-pole switch, of which illustrations are given. The principle of its operation consists in automatically opening the switch by the action of a spring immediately upon the blowing of the neutral fuse, the switch being maintained in its closed position by a latch or catch. This latch is released, or withdrawn from its locking engagement, by the attraction of a small electromagnet having its terminals connected to the ends of the neutral fuse. So long as the fuse remains intact no current flows through the windings of the magnet, as the potential at its terminals is only that due to the drop in voltage in the neutral fuse itself. Upon the blowing of the fuse, however, the potential between the points of connection immediately rises, causing current to flow through the magnet coils, thus energising the magnet sufficiently to enable it to release the catch. Although the winding of the magnet is in parallel with the neutral fuse, it does not in any degree affect the carrying capacity of the latter, as the resistance of the coils is great relatively to that of the fuse. The opening of the switch follows so closely upon the blowing of the fuse that it is said to be practically impossible to distinguish the interval which separates the two occurrences. L. J. S.

1097. *Long-distance Transmission Experiment at Ogden.* (Elect. Rev. N. Y. 32. p. 287, 1898.)—This experiment was carried out at Ogden, Utah, in order to ascertain the limits within which high-voltage currents may be used commercially. The experiment was made by F. O. Blackwell over the lines which connect the power station at Ogden with the distributing circuits at Salt Lake City, the complete transmission circuit being 73 miles long over three No. 1 wires. The amount of power transmitted amounted to 1000 horse-power, and the transmission voltage at times reached 30,000 volts. The current on the return was delivered to resistance-vats at the power-house, consisting of three wooden tanks. This power was transmitted with a loss of only nine per cent., including four per cent. loss in the two sets of transformers. Continuing the experiment, part of the Salt Lake City station load was run from Ogden with current at 24,000 volts. This was supplied to about 500 horse-power in synchronous motors and lights for two days under severe climatic conditions without the slightest hitch. W. G. R.

1098. *St. Anthony Falls Water-Power Plant.* (Amer. Electn. 10. pp. 185–192, 1898.)—These works were recently constructed by the St. Anthony Falls Water Power Co., and on completion were leased to the Twin City Rapid Transit Co., to furnish power for street railways in Minneapolis and St. Paul, supplanting the steam-driven machines at first installed. The site of the generating works is in Minneapolis, just below the St. Anthony Falls on the Mississippi. A V-shaped dam, with a crest about 1000 ft. long, has been constructed of cut granite, and gives a maximum head of 22 ft.; it is provided with sluices, waste weirs, etc., of which a full description is given. The power-house, which forms part of the dam, contains room for ten 700 K.W. sets, seven of which are now installed, and two smaller sets for supplying exciting current. The main turbines consist of two pairs of 42-in. horizontal water-wheels on the same shaft directly connected to a generator; the sluices for each set are regulated by a governor driven by belting off the generator shaft. In the generating station there are already installed five three-phase alternators yielding 700 K.W. at 3450 volts with frequency about 35; two 700 K.W. direct-current dynamos feeding a 500-volt railway circuit direct; and two 100 K.W. 6-pole exciters. There are three substations: to No. 1, about 1⅔ miles distant, current is transmitted at 3450 volts and actuates two 600 K.W. rotary converters; these are of the 8-pole type giving 580 volts on the direct-current side at 530 revs. per min. No. 2, situated about 4½ miles from the main station, contains one rotary converter of the same type supplied at the same voltage. No. 3, ten miles distant, is supplied at 12,000 volts, and contains two similar converters. Twenty-one 233 K.W. transformers are installed, six at the main station and fifteen in the substations. The transmission is by paper-insulated lead-armoured triple conductors laid underground, two leading to substation No. 1, and one each to the other substations. The paper is illustrated by eighteen views of different parts of the plant. M. G. W.

1099. *Booster System in Electric Railways.* **J. L. Woodbridge.** (Frank. Instit. Journ. 145. pp. 374–385, 1898.)—Booster is any electro-magnetic generator whose armature is connected in series with a feeder with the object of compensating for drop of voltage in that conductor due to the current which it is transmitting. In lighting and traction work it has proved very useful, rendering it possible to take up loss in feeders too long to form part of the main system. In every case of heavy drop in feeders, boosting involves difficulties in keeping uniform voltage along the whole line. It is practically equivalent to a very strong over-compounding, reinforcing the system only in the needy branches. Any spare generator in the station can be used for the purpose. A "compound series booster" is simply an ordinary compound-wound constant potential machine, connected by a double-throw switch, to serve (1) as a booster when required, or (2) as an ordinary generator. The shunt-coils are connected in parallel with each other and with a certain portion of the feeder, so that a small but constant percentage of current circulates through them, and, like the series coils, the magnetising force is proportional to the load, obtaining thus the series effect from both shunt and series windings. The variation of voltage is carefully gone into, and its causes inherent in the booster machine. (1) Saturation of field-magnets. When using a machine on hand with this fault, remedy it by limiting the load, or providing sufficient copper in the feeder to limit the maximum voltage required and range of magnetisation. (2) Hysteresis effects have little importance in railway work owing to the peculiar nature of the variations of load. (3) Sluggishness, due to inductance and Foucault currents. The effect of high inductance of shunt-fields are rather more serious, and this is minimised by limiting the extent of their magnetising force by dividing them up in parallel, thus tending to check the portion which will lag. As a rule it is not advisable to operate the booster continually, but to put enough copper to carry ordinary loads satisfactorily, reserving the booster for times of excessive traffic. But with a low price of fuel it pays to use a booster for as much as 18 hours a day. The booster system, if used with skilled judgment, may save a large expenditure in copper at the cost of an amount of wasted energy that is well within the limits of economy. P. D.

1100. *Accumulator Traction.* (Electrician, 41. pp. 9–10, 1898.)—An abstract is given of a report drawn up by a deputation of the Blackpool Corporation after visiting various Continental systems of electric traction. The estimated cost is given of supplanting the present conduit system by accumulator traction. The rolling-stock consists partly of double-bogie cars weighing 11 tons and partly of smaller cars weighing 7¼ tons. The relative costs of maintenance work out to the following figures :—

Overhead system	£600
Conduit system, cost during 1897 .	2238
Accumulator system.............	2799

W. R. C.

1101. *Accumulator Road Traction.* **J. T. Niblett.** (Mech. Eng. 1. pp. 520–531, 566–568, 607–609, 628–629, 1898.)—A variety of forms of storage-cells—both obsolete and in present use—are described, and some elementary data given concerning the calculation of internal resistance, efficiency, and so forth. Many particulars as to the construction and working of the electric cabs now running in London and in New York are also given. The former carry 40 Faure-King cells having a total weight of 14 cwt. and an output of 170 ampere-hours when discharging at a 30-ampere rate. One motor of the Johnson-Lundell type is used, capable of normally developing 3 horse-power, and provided with double windings on both fields and armature for the purpose of obtaining the various speeds. The latter contain 44 3-plate cells of the chloride type, whose total weight is 900 lbs. and capacity 100 ampere-hours at a 21-ampere rate. Two motors, each of 1·5 horse-power at 800 revolutions, are employed. E. J. W.

1102. *Electric Traction.* **G. Pellissier.** (Écl. Électr. 14. pp. 449–456; 15. pp. 63–67, 140–143, 187–189, 1898.)—The author gives an account of various patents relating to electric traction. Among the number are included the Blackburne and Spence system of traction, the Priest and Merrick pneumatic series-parallel controller, the MacElroy truck, the arc-trolley of the Industrie Électrique Company, and that of Siemens. Some account is given of the New York conduit-lines. The author then describes the conduit systems of Griffin and Small; Hecker; Allen; Nigel, Harington, Balfour, and Smith, in which a small trolley within the conduit is magnetically attracted by the car and thus caused to run with it, making alive the various sections of a rail on the surface; of Siemens; and of Arno and Caramagna. W. R. C.

1103. *Counterweight System in Electric Cable Tramways.* (Street Rly. Rev. 8. pp. 286–288, 1898.)—The grade of the tramway begins at 5 per cent., increasing gradually to 16 per cent., then falling to 4 per cent. The vertical height attained is more than 100 ft. In going up- or down-hill, each passenger-car is controlled by a grip-car immediately below it on the grade; the grip-car is attached by a gripping device to the cable, and a counterweight running in a tunnel half the length of the tramway balances the weight of the cars. There are thus no counterweight cable fastenings and draw-bar connections. A number of drawings are given illustrating the mechanical construction of the line.

A. S.

1104. *Electric Street Railways in Baltimore.* **C. B. Fairchild.** (Elect. Engin. N.Y. 25. pp. 569–571, 1898.)—This is a description of the Baltimore City Passenger Railway, which is about to be transformed into an electric line. Formerly the cable cars were operated in trains, consisting of an open grip-car and trailer. The train system still remains; but the open grip-cars have been converted into trailers, and the closed cars used for the grip-car.
W. G. R.

1105. *Best Arrangement of Return Feeders for Traction.* **F. Natalis.** (Street Rly. Journ. 14. pp. 277–283, 1898.)—To tramway engineers the arrangement of the return feeders is an important question. The rails alone are seldom of sufficient carrying capacity for returning the current to the power-station. Large potential differences between two points on the line are not admissable, on account of so-called "vagabond currents," which disturb telephones and scientific instruments, ruin pipes, etc. The local authorities usually insist upon a definite maximum fall of potential on the return circuit. Return feeders are at best expensive; and if their number and locations are unwisely chosen, their cost of construction is considerably increased The author gives a number of formulæ and examples for settling this important question, and concludes this article by stating that, considering what great expenses are often involved, it is well worth the trouble to make use of such formulæ. In these calculations, as well as in many similar ones, many things must of course be left to the judgment of the engineer.
L. J. S.

1106. *Rail-Bonding.* **J. R. Chapman.** (Street Rly. Rev. 8. p. 347, 1898.)—A cast-welded joint in a 56-lb. rail, which had been in use for 2½ years and was worn out, was tested, with the results tabulated below, showing that the conductivity of the joint was practically equal to that of the rail. The joint was afterwards sawn through; a view of the section is given.

Test No.	Average Amperes Flowing.	Drop in 5 ft. with Joint.	Drop in 5 ft. without Joint.	Drop in Volts per 100 Amperes Flowing.
		volts.	volts.	
1.	502·6	......	·047	·00935
2.	508·9	·048	......	·00943
3.	735·8	·065	......	·00883
4.	758·8	......	·069	·00910

Temperature of rail during tests, 80° F.

A. H. A.